The
GEOGRAPHICAL JOURNAL

Vol C Nos 5, 6 R.G.S. *Nov.—Dec. 1942*

A NEW ERA IN THE GOBI

MISS MILDRED CABLE

Meeting of the Society, 26 October 1942

THE subject of this evening's lecture being "A new era in the Gobi," there must be some clear understanding of the term Gobi, with a statement of what is the area to which it is applied, as well as what have been the accepted conditions of life within its border. To quote from the 'Géographie Universelle' (P. Vidal de la Blache et L. Gallois):

"*Gobi* n'est pas le nom propre d'une contrée. C'est un terme de la langue commune des Mongols, désignant une certaine catégorie d'accidents géographiques, de larges cuvettes dont le fond de rocher, très peu creux et presque uni, est revêtu de sable, de cailloux et surtout de graviers. . . . L'ensemble de ces accidents constitue le grand désert de Gobi des géographes européens. Le Gobi mesure près de 1200 kilomètres du Nord au Sud vers le 104e méridien, plus de 2000 le long du 44e parallèle. Au Levant il déborde de 500 kilomètres le Khingan central. Au Couchant, il ne finit qu'avec l'emploi du mot *Gobi*; mais en effet il se prolonge sans interruption par les déserts de la Djoungarie et du Turkestan oriental, que sépare l'un de l'autre la bande montagneuse et fertile du Tien-chan. Du Pamir jusqu'aux confins de la Mantchourie, il compte ainsi 3600 kilomètres."

The Chinese, with instinctive insight, have selected two ideographs to represent the sound "Gobi" which, literally translated, mean "A wall of spears," and this, the Gobi has certainly been for those who would cross it, for they must face not only hardship and fatigue, but the perils of sandstorms, blizzards, thirst, robbers, and, should they lose their way, the risk of a terrible death. These terrors have led to the extreme isolation of its peoples, and though the Desert is traversed by great trade-routes which connect China with Russia, Mongolia with Kashgar, and Siberia with Northern India, the people of the oases have lived a life governed by their own peculiar customs, traditions and beliefs, and whose intimacies have remained largely unknown to casual travellers on Gobi highways. The control of those trade-routes was the ambition of conquerors long before the Christian era, and among modern statesmen the more far-seeing have realized that whoever held those great

arteries would have his own way among the strange people of the oases and the nomad encampments.

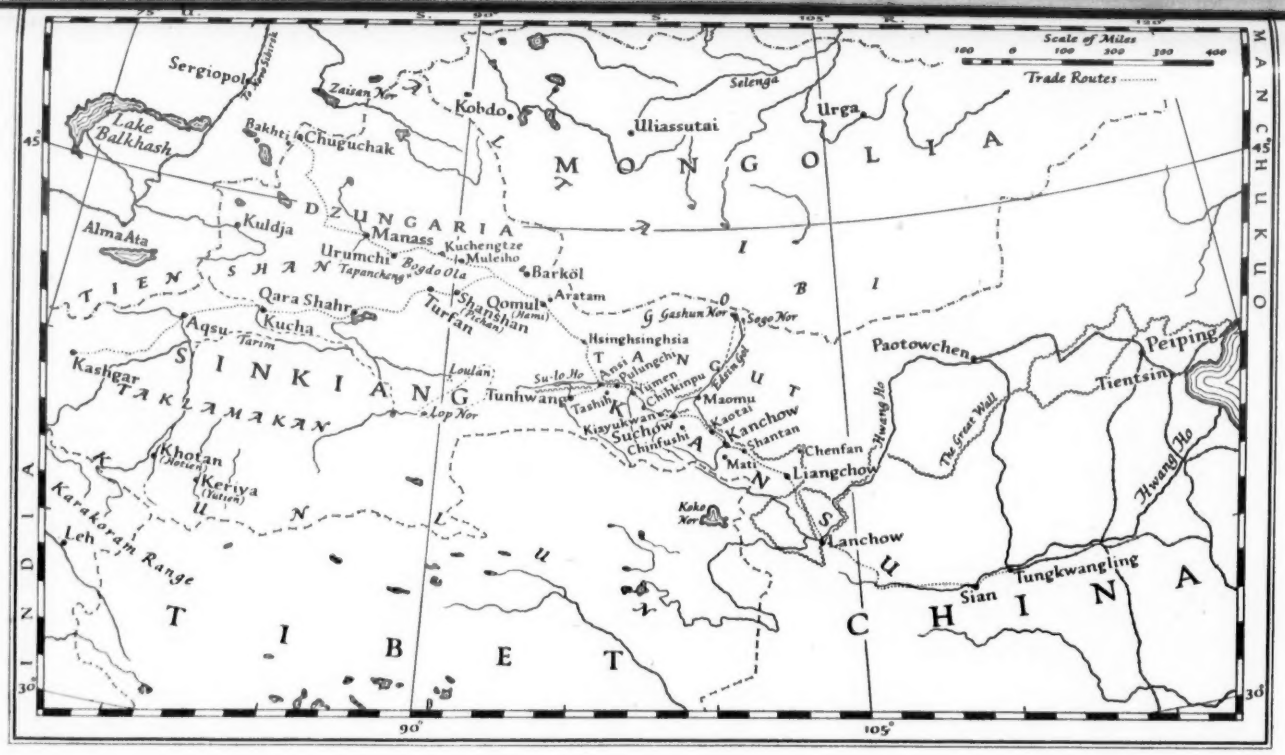
When I first entered this desert region I noticed with what fear my Chinese companions passed the great gate of Kiayükwan, called by the local inhabitants Kweimenkwan—the Gate of Demons, which is the entrance to that land spoken of as being "Without the Mouth." This fortress, which commands the main part of the Great Wall of China on the western side, has several gates, the most picturesque of which is the "Door of Necessity" through which water is brought to the fortress. The three distinctive towers which have always been the landmark for travellers returning to China, are now broken and ruined because a band of brigands, needing the wood with which to make fires, pulled down the pillars of the fortress outlook. The approach to Kiayükwan from the east is striking, but the exit on the west is terrifying when the blizzard blows and the traveller hears the great gate close behind him and the bolt being shot, while ahead lies barren, unknown desert. I shared with my Chinese companions that fear of the unknown, but my business took me there, so I went on.

I found Gobi to be totally unlike anything that I had pictured. For one thing, its variety surprised me. Many of the smaller oases were scarcely visible until I walked into them, for chameleon-like, they adopted the colour of the earth and merged into the landscape. I passed through sandy parts of the desert, some of them near the City of Sands, where great dunes changed their contour as the wind blew over them. I came to desolate expanses where utter barrenness reigned. In some regions there were old towns buried by the sands, towns which had been abandoned either because the underground water supply had failed or, in other cases, because of revolts and wars so fierce that the inhabitants, abandoning all their possessions, had fled before the ruthlessness of their conquerors. When the humans had gone the sands encroached and gradually covered over the scars of man's devastating onslaught, but when the winds blew, old vases, seals, and other treasures came to the surface, such as pots which, I am told, bear the stamp of great antiquity.

Sometimes the track lay across Black Gobi, where small black stones covered the desert floor and there was no relief from the burning sun or from the biting cold. Occasionally the caravan moved among mounds of loose silver sand, and there the desert *Wutung* tree grew—the tree whose lower branches bear leaves like those of a willow, while those on the higher branches are like the leaves of the poplar—a tree full of meaning to the Chinese and to the Mongolians. It symbolizes sadness, for it is the first tree to lose its leaves in autumn, and a filial son should lean upon the staff of the *Wutung* at the funeral of a parent.

This desert was not always one great flat expanse. There were barren hills, flame-coloured and so hot that the natives speak of them as being cursed by Allah. I came upon bare rocky ranges which were strangely coloured, one hill might be so green that it gave the impression of being covered with green lichen while others were rust-red or tender pink, and on the stony ground the colouring was sometimes so vivid as to form a real rock-garden, that is to say, a garden of stone, not of flowers. Colour photography was impossible out there, because so long must elapse between the taking of the picture and its

M
Scale of Miles


Scale of Miles
100 0 100 200 300 400
Trade Routes
Sergiopol
Lake Balkhash
Zaisan Nor
Kobdo
Uliassutai
Urga
Selenga
Bakhti
Chuguchak
MONGOLIA
DZUNGARIA
Alma Ata
Kuldja
Manass
Kuchengtze
Urumchi
Tapancheng
Bogdo Ola
Muleiho
Barköl
TIEN SHAN
Qara Shahr
Turfan
Shanshan (Lekkan)
Qomul (Hami)
Aratam
Gashun Nor
Sogo Nor
Aqsu
Kucha
Tarim
Hsinghsinghsia
Ansi
Pulangchi
Yumen
Chihkinpu
Su-le Ho
Loulan
Tunhwang
Lop Nor
SINKIANG
TAKLAMAKAN
Kashgar
Khotan (Hotien)
Keriya (Yutien)
Karakoram Range
Leh
TIBET
Tashih
Kiayukwan
Suchow
Chinfushi
Maomu
Kaotai
Kanchow
Shantan
Mati
Chenfan
Liangchow
Koko Nor
Lanchow
Sian
Tungkwangling
Paotowchen
Peiping
Tientsin
Hwang Ho
The Great Wall
CHINA
MANCHUKUO
INDIA
75°
90°
105°
120°
30°
45°

1. A section of the Great Wall of China

2. The road between Pichan and Barköl

development, but I collected a number of these stones, put them in a bag, and brought them home, where they have been photographed in natural colour with remarkable effect. At the Turkistan border of Hsinghsinghsia is a mountain pass, of which one glittering hill of quartz stands out in fairy-like beauty on a moonlit night. Again there are salt lakes where the salt-impregnated soil was cut into blocks and sun-dried, then used for building the shacks.

In some stony places water rises from the subsoil, and in the evening the caravan *bash* calls his men to water the camels at the precious pool, and the leisure hour while the cook boils the millet porridge, is spent by the missionary in wayside intercourse. The oases revealed great variety, and from some which were a mere cluster of small shacks round a water-hole, I travelled on to busy cities like Hami, Turfan, and Urumchi.

Desert landmarks are always interesting, and generally indicate the presence in that neighbourhood of some division of the track, or of some object of interest. In the desert dryness such earthen monuments will last for centuries.

The Gobi lured me from place to place, disciplining me by its spirit of austerity, strengthening me to endure its hardships, and then, as if in compensation for its rigours, it took me to see some of its hidden treasures. I found its singing sands, the marvel of which I had read but never heard; I saw the great horns of its wild sheep and measured them with astonishment; I visited its caves of the Thousand Buddhas, whose frescoed walls had been preserved for more than a millennium by the desert sand, and I rested by its Lake of the Crescent Moon. I saw its old Graeco-Buddhist ruins, such as the Tower of Sirkip, and the walls of Dakianus in the Turfan Depression, where Grecian influence can be traced in paintings and frescoes, and where I could think back over centuries of history and realize that though conquerors trampled the people underfoot in their lust for power, conquerors passed away, but the people remained and life went on.

I tramped the desert highways for one purpose only: that as a missionary I might reach its surprisingly varied people. These people my comrades and I learnt to know and to love, and to find ourselves equally at home within the Palace of the Khan, the *isba* of the Russian, the tent of the nomad, the courtyard of the Chinese, and the *oy* of the Turki. I talked with the veiled moslem women, the Turki Mullahs, the Mongol herdswomen at their tent doors, the inn-keepers of the main road, such as the innkeeper of Pichan who would never let me pay for my lodgings. I met priests in wayside temples, Kirghiz who rode down from the hills, and Qazaq women, who, while still living in tents, had children in Siberian colleges.

In order that I may make more clear the great changes which have taken place in the Gobi I must take a few moments to speak of things as they were. This desert area gave allegiance to an hereditary ruler, as I realized when for the first time I noticed an engraved stone standing by the wayside. On this stone was an inscription indicating that it marked the boundary of the area controlled by the King of the Gobi. When I began to make inquiries about this King I was reminded that the renowned Genghiz Khan appointed his son Jagatai to rule the land surrounding the present oasis of Hami, known also by the name of Qomul, and from that period, Qomul has recognized the

authority of a Khan. The present ruler was Maksud Shah, and he lived at Qomul. When I first came to the town, Maksud Shah was already old and realizing that he had not many more years to live, the talk of Qomul, more specially among the astute Tungan merchants, often centred on the new era which must come to the South Road oases when he should die.

Maksud Shah as a young man visited Peiping every sixth year and was permitted to serve the Emperor as personal servant. Qomul also sent a yearly tribute to the Imperial court which was particularly welcome, for it included a large consignment of its famous melons which were so well appreciated that a popular saying was current in Peiping:

"With East Sea crabs and West Sea *hsia* (shrimps)
Stand Turfan grapes and Hami *gua* (melons)."

In return Her Imperial Majesty, the Empress Dowager herself, wrote scrolls which Maksud Shah brought proudly back to his Gobi Palace. The brushwork showed surprising strength and virility. From the palace I went to the flower gardens enclosing a beautiful lotus tank, the inspiration of which had doubtless come from the sight of the lotus moats which surrounded the Forbidden City in Peiping and among the winding paths peacocks spread their gorgeous feathers.

A western visitor once asked the Khan how far his territory extended. With a sweep of his arm the desert monarch indicated the snowy range of the Barköl mountains: "All that you can see is mine," he said, "and more that you cannot see." It was a true answer for those mountain slopes were his pasture lands; and numerous oases acknowledged his rule and brought tribute to his palace, but his unique title remained Khan of Qomul and King of the Gobi.

The King of the Gobi had his palaces, he also had his own secret service, but it was of an order which gave no trouble to the people, and quite unlike the irritating network of secret police which they came to know later, those who formed it accepted their responsibility quite simply as a normal part of Gobi's life and tradition. There is a Gobi saying concerning two of its towns, that "Pichan and Barköl are the Ears of the Gobi." Knowing the genius of oasis men for applying a nickname, I asked how the word "ears" could be applied to towns. "When you have been there you will understand," was the answer, and it proved to be a correct one.

I went first to Barköl, a town situated behind the great range known to the Chinese as the Ba-li-kuen mountains and to the Turki people as the Karlik Tagh. We travelled over a mountain pass which led us up a steep and winding track, but when we reached the top we saw the town lying below, and not far away was the blue lake of Barköl where the wild asses play. The town was cut off from the main Turkistan high roads on one side by the range of snow mountains and on the other by wide stretches of arid land. The inhabitants were some of the most conservative Chinese I ever met. They lived by tradition and old customs and courtesies were still in use which had long vanished elsewhere. At Barköl all foreign goods and ways were scorned and Westerners have always met with a cool reception from its officials. Its inhabitants cared nothing for doings in the West, and Turkistan, though so

3. The Caves of the Thousand Buddhas

4. The tower of Sirkip

5. Mounds of loose silver sand

6. A desert landmark

7. The sand-hills of Tunhwang

ear, meant little to them. Their intercourse was with Paotow on the Yellow iver, and with Peiping, for that was where their interest centred. The Gobi ept this ear extended eastward, always listening to what concerned China, nd ever since I heard the nickname I visualized this secretive town as an ttentive ear, listening and hearing much, but never telling what it knew.

The Gobi's other ear is the town of Pichan on the South Road, near Turfan. Lumbering carts from Kashgar came there bringing loads and ravelling merchants from western Turkistan, and here they met the stream f west-bound traffic from Kiayükwan. The crowds were excitable, communicative, mobile, and hurried. Every one was eager for news, which came om over the Himalaya, or from Tashkent, or Alma Ata. The listening ear f Pichan was directed toward the west, and alert to repercussions from India, fghanistan, Russian Turkistan, or from Europe. It heard of riots in alestine, of Moslem demonstrations in India, of strikes in Europe, and of rastic purges in Russian-controlled lands.

The great Genghiz once rewarded a general who had shown his trustorthiness by saying to him: "Henceforth you shall be eyes and ears for me." hese two oases have taken to themselves the honour of being the far exnded ears of Gobi, but it would be a great statesman who would have isdom enough to sift all the news which reaches these ears and adapt his olicies to govern justly all the varied peoples who form the tribes of Central sia.

The death of Maksud Shah in 1930 marked an epoch in the history of the obi. The old man could not in any sense be called a model ruler, but he pheld the tradition which came to him from his ancestors, and ruled the omul area as Genghiz himself had ordained it should be ruled. The time r a Moslem rebellion was drawing near when I was there because the adition that they rise once in thirty years has become so much a part of entral Asian moslem thought, that when the time approaches every man stinctively prepares for action.

For many years past Gobi's eastern ear had been listening to stories of evolt, of the fall of dynasties, of war-lord rule and of such changes as had ever been dreamt of as possible, while its western ear also heard disquieting ews. Wars in Europe led to the Tsar of Russia's dethronement, then crowds f Russians came over the great highway, men and women who had escaped om the land of their birth. White men were seen begging their bread in e bazaar, and all preconceived ideas of Westerner's superiority were overurned. Could white men then be reduced to beggary, and white women ach such poverty as only to be saved from starvation by becoming secondary ives to Chinese or Turki husbands. The prestige of the West received a ude shock and the sign of a new era was evident when isolated Gobi began feel repercussions of the European war.

The first noticeable change in the life of the people was the need for travel ermits to enable caravans to cross the Turkistan frontier. The Governor t that time was Yang Tsen-hsin, an astute man, who determined to guard is province from disturbance, and when banditry made travel in China roper most perilous, the Gobi was still safe for caravans. No one might nter or leave the province however without his personal permit, and I myself

have been kept for days at the border oasis of Hsinghsinghsia until permission came for me to proceed. The governor was taking no risks, but having satisfied himself that we three women were not political agents, he allowed us to proceed. We were even given a great welcome and nothing could have been kinder than our reception at Urumchi, where he was prepared to help us in our missionary work among his people.

We could not fail to realize that sinister influences were already at work, and Governor Yang must have known that enemies were plotting against him. In an endeavour to check them, he tightened up control everywhere. Later on a conspiracy in his own *entourage* was discovered, and he dealt with it in a way which has left a lasting stain on his memory. He invited the conspirators to a feast with other guests, and himself sat down with them, but when the wine had been poured out he left the hall and returned followed by a soldier. At his command one instigator of the plot was beheaded on the spot, then a second conspirator fell dead, after which Yang resumed his seat, and the gruesome feast proceeded as though nothing had occurred. The Chinese have a proverb, "He who murders at a feast, at a feast shall his blood be shed," and in 1928 Yang himself was also murdered at a feast by his own Minister of Foreign Affairs, Fan Yao-nan.

Fan was a silent, stealthy man, who had been educated in Japan. From the time of his arrival he and Yang disliked one another, and Yang offended him by changing his appointment and giving him a less important post than that for which he had been designated. Fan had for long wished to leave Turkistan, but the tyrannical control which made life in Urumchi a torment to many prevented him from leaving the province without the Governor's written permission, and this was refused to him. He watched for a chance of revenge and the occasion occurred on 7 July 1928, when Yang was guest at a graduation ceremony at the Russian School of Languages. Fan brought with him a number of his own men in the guise of language school students, and when the feast was served shots were fired, and Governor Yang fell dead. Fan himself was executed the same day by order of Chin Shu-ren, Minister of the Political Department, and next in office to Yang himself. Chin then became Governor, and all the foundations laid by Yang for the future progress of Turkistan crumbled under the rule of a weak, vacillating opium smoker. The death of Yang Tsen-hsin removed a strong personality from the governorship, and soon men everywhere complained of grievances arising from the unreliable actions of the new Governor, but the death of Maksud Shah brought matters to a head among the Turki people who were ripe for revolt. His heir was taken to Urumchi and deprived of his liberty, new officials appeared in Qomul and the man who had been Vizir to the Khan Yolbas the Tiger Prince, found himself in the new position of receiving orders instead of issuing them.

Wandering through the Summer Palace where we were staying at the time of Maksud's death I came to a large hall where stood the empty throne of the Khan. There was something which touched me deeply as I looked upon this simple symbol of authority with the desert iris painted upon it. The ruler was dead, the new order was dawning and a rule which though perhaps inefficient and medieval, was liked better than any other by the people, was

8. Desert grass

9. Talking with Mongols at their tent door

10. Inside a yurt

11. Oasis of Liaotung, squalid inns

12. The inn courtyard

over. No other Khan will sit upon that throne for it was burnt to ashes, together with the structure of the Summer Palace, in the civil war which followed.

At this time there came on the scene a young man who has made history in Central Asia: Ma Chung-ying, known as the Thunderbolt on account of his ruthlessness, and also as the Baby General on account of his extreme youth. Believing him to be possessed by the spirit of a dead warrior, Moslems followed him and obeyed his orders whatever they might be. He gathered an army round him and, using such methods of terrorism as have since become strangely familiar to the west, he wiped out the male population of each town which refused to receive him. I have seen the officials of a Chinese city cower before him and hand over their firearms, then feast him with the best the oasis could produce, giving him their stores of grain and reserves of silver while young Ma took over control.

The Moslems of Turkistan hearing of this youthful warrior asked him to be their leader and to become governor of a new Turkistan with the name of Islamistan. To win such a campaign was after the Baby General's own heart. In the summer of 1931 he marched across the Gobi and captured the arsenal of Barköl, which was a large one. Later on he showed me with great pride numbers of rifles he had secured there, pointing out their British manufacture.

After seizing the arsenal he proceeded to attack Qomul, which he besieged for six months but failed to capture. The brave defenders used the most ingenious methods against Ma, and in the end shot fire arrows which they found in an old part of the city at his army. Failing in his objective, Ma, again strangely reminding us of his European counterpart, said that his patience was exhausted and that really Qomul was not worth his steel, and he would proceed to Urumchi at once. The armies of the Governor met with Ma's men in the desert and the government troops were defeated, but Ma was wounded and his men, at a loss to fight without their mascot, carried the sick man back across Gobi and handed him over to me to cure. Perhaps unfortunately, the treatment was successful, for in due course he was off on another raiding expedition to Turkistan. When finally I myself escaped from his control and reached the safety of government troops I found that I should have been a more popular person had I finished him off, or at any rate, helped him to become permanently lame. The civil war following Ma's campaigns led to terrible slaughter, and reprisals on both sides were carried out with shocking ferocity. In the end Ma was captured by Russian troops and taken to Russia. The world may yet hear more of this young man. It was during his campaigns that the government of Turkistan first called in the aid of the Soviet Union, and though I cannot dwell upon this I can record one or two clauses of the treaty which was finally signed on 1 October 1931, by Comrade Slavutski, delegate of the National Commissariat of Foreign Affairs, and Mr. Chen, plenipotentiary of the Sinkiang Provincial Government. It gives to the U.S.S.R.: The right (post factum) to open trade agencies in the towns of Urumchi, Chuguchak, Kuldja, and Kashgar; the right to open offices in the towns of Aqsu, Kucha, Yarkand, and Khotan; and the right of unrestricted movement of representatives of trade organizations and Soviet

citizens for purposes of trade by defined routes between the above-named towns—that is, over the whole of Sinkiang.

The treaty further provided for: Reduction of duties by the Chinese Customs Houses on goods of Soviet origin; telegraphic connection between Chuguchak and the U.S.S.R.; the right to send radiograms from stations in Sinkiang (Urumchi, Kashgar) to stations in the U.S.S.R. and vice versa; and the opening for transport of the road from the U.S.S.R. to China *via* the Turugart Pass.

On the other hand, Sinkiang obtained: The right of transit for Chinese merchants of goods of Chinese origin across Siberia from Sinkiang to eastern China and vice versa; and the Provincial Government of Sinkiang "hoped" that in view of its "historical" interest in the development of commercial relations between Sinkiang and the U.S.S.R., the Soviet Government would assist Sinkiang in the organization of transport, in electrification, and in measures for the improvement of agriculture in Sinkiang; also that the Soviet Government would send specialists to Sinkiang to train Chinese citizens.

After the conclusion of this pact I found how swiftly and how radically conditions had changed in Urumchi. Schools were more efficient, new text-books had been introduced, and Russian was taught as a second language. The more promising pupils were taken to large towns in Russia for higher education. Colleges for specialized training, such as schools for veterinary surgeons, were opened in the large cities, and Mongol youths were specially urged to take advantage of them. Every office in the larger oases had a Russian advisor, and the Soviet Government fulfilled to the utmost her undertaking to send officials and train the Chinese. Small hospitals and dispensaries were established all over the place, and young Qazaq and Uzbek girls began to train as nurses.

But religion was regarded as superstition. Moslem patients complained that they received a stern rebuke if they called on the name of Allah, and a Christian Mongol whom I knew had to choose between the possession of his Bible and his further training. Strict censorship was imposed on all mails, and whereas the Chinese Post Office had been in the past the place where every possible help was given to familiar travellers, it now became a place where everyone was afraid to speak or be seen with any one else. It was, however, I am sure, a Chinese who had the humour to place a large placard over the censor's office, stating: "It is forbidden to entertain any feeling of animosity towards the censor." So far as I was concerned I did not even try to obey it.

Ma Chung-ying, by creating a condition of panic, had prepared the way for a new era of government in Sinkiang, and it took the form of such a rule as the Chinese people are incapable of enforcing, except it be under pressure from some outside power. Governor Chin was unsuited to a post of authority, for, one day overbearing with his friends and another day craven and abject before evil men, he ruled by terrorism, nurturing that strange illusion which falls on dictators, that silencing men is tantamount to conquering them.

The simple peasants who understood little of the causes of all this turmoil,

bowed their heads before the storm and waited, but life was made bitter for them by the difficulties which followed in the train of Governor Chin's ridiculous financial policy. There was no paper shortage, and what easier than to print tens of thousands of tael notes as required. I knew some of the men in the paper money department, and often saw them between their terms of imprisonment, for to bring home a few bundles of notes was a tempting proposition, and even if they were not guilty of this crime some enemy would accuse them of it and they would be equally punished whether innocent or guilty.

Outside the towns peaceful Gobi homes were left desolate, farmsteads were burnt, the trees of the oases hewn down, and the young men were recruited for brigand bands. Many of the oasis wells were filled up with sand, and double stages had to be covered in order to reach water, but the inns were untenable because men's bones and dead men's clothes littered the mud rooms and lay about in courtyard enclosures. The palaces of Hami were destroyed and nothing but rubble remained where once a medieval court had held sway.

The old caravan *bash* was no more to be found and the only drivers I could hire were ruffians who took advantage of my travel permit to get away from the capital, and slip over the frontier to Kansu, where there was comparative liberty and freedom of movement. The skilful, philosophical old caravan leader, the *bash* who taught his "guests," as he always called his passengers, how to cross a desert, how to guide a course by the stars, how to walk safely by starlight, how to distinguish between a true human voice and the calls of demons, how to pack the caravan, and how to detect a mirage had vanished.

Instead of the familiar call from one caravan driver to another,"Where do you hail from, and whither bound," the raucous hoot of lorries laden with wretched passengers hanging on to the ropes which bound the merchandize to the truck was heard. The mud *serai* with its austere conditions vanished before the stucco-fronted Hotel Marco Polo, where travellers were housed by the motor company. Travel permits, secret police interrogations, and registration forms, were the order of the day. At regular points luggage was examined and passengers were questioned lest they smuggle contraband letters or parcels across a frontier. The spirit of Gobi culture was replaced by fear, suspicion, and treachery.

In some places the motor road and the old cart road ran side by side, and I was urged to cross the Gobi by motor lorry, but I simply could not have done it, if for no other reason than because my business as a missionary required me to seek the homes of people whom I knew in places where no motor lorry would stop and allow me to share with them once more the simple desert hospitality.

Travelling where I was accustomed to meet veiled women I now found schools established, not only for boys but for girls who would formerly have been in the harem and were now free to come out and attend classes, and even march in procession with the boys to the drill-ground. On such occasions the boys were in Scout's uniform, and the girls paraded in a dress similar to that of Girl Guides. The slogans were "Liberty for all, freedom for all, equal

rights for all, progress for all, plenty for all." Songs were sung, of which I quote the translation of one which was typical:

> Lo, in the East, from burning eyes
> Of million souls flashes one will:
> Ye brown-skinned women, haste to work, unveiled ye weave
> The dawn's red glow.

A new era had dawned. It came by way of revolution, blood, and suffering, and overtook the desert dwellers who had remained unaffected by the wild doings of men in the rapidly changing West. At first, the older people were dazed, baffled, disturbed and unhappy, but the younger generation of Gobi never stayed to knock at the door, but burst it open, caring nothing for threats or tears from their elders. The fresh wonders of the new era were never ending, and soon, not only the motor lorry tore over the Gobi spaces, but the aeroplane was seen, and even the heavens were invaded and desert dwellers looked up to see the monster that they described as a "flying cart" buzzing through the skies.

Yet, with all the new facilities no one now might move from one city to another without a police permit, and though education was given freely, no one might send a letter unless it passed through the office of the censor. There was a wireless installation in Urumchi and loud-speakers appeared on the city wall, but no one might own a wireless set, and the former news-carrier who brought information concerning world happenings and told it in the market-places, would now only speak under cover of darkness, and in the house of a trusted friend.

All the happy, easy intercourse of the desert trade-routes, and of Gobi homes, where men had shared with each other the happenings of the way, was dying. The men of the water-holes, ignored by the harried passengers of the motor trucks, gradually disappeared, and the Old Silk Road, which had been famous in the days before Christ, now received a new name, and appears to-day in some modern maps as "The Red Highway," for over it, no longer silks for the ladies of Rome, but ammunition and instruments of death must pass. Technicians are at work testing bridges, marking out roads, blasting rocks, and it may be that the Gobi will soon be crossed by iron rails and shrieking engines. I am told that I cannot put the clock back and that civilization must march on. I admit that this is true, but desert spaces, simple conditions, and slow travel symbolize an aspect and a quality of life to which the age of machinery is inimical. For millennia the Gobi has supplied the conditions in which man, brought face to face with reality learns by inexorable experience that basic things such as bread, water, and the fundamental interdependence of men, are of greater importance than the struggle of any individual to impose his dreams of power on his fellows. There is something in man which requires time, space, silence, and a wide horizon for his development, and that something is the capacity to view current happenings with a poise which measures their actual value and true place in the whole scheme of things. That poise is destroyed by the artificialities of western life.

Leading statesmen are now flown from Moscow to Chungking in a few hours, but had they been obliged to traverse the Gobi at the old foot-pace they

might have learnt in those long months of travel things which would supply a solution to many a world problem. The Gobi may yield coal, iron, gold, copper, mineral oil, and raw cotton as well as many other coveted products to its exploiters, but the spirit of the desert will withdraw at their approach and leave the land to them. The invasion of the Gobi and the new era which has dawned may be called a great advance by the invaders, but will the world have gained? I think not.

NOTES ON ILLUSTRATIONS

1. *A section of the Great Wall of China*

The line of the Great Wall from its eastern end can be seen for a very great distance as it loses itself in hollows and re-emerges to crown some distant height and disappear again on the farther side. The traveller who skirts the frontier of north China and Mongolia follows its course through weeks of the long journey before reaching its extreme western point at Kiayükwan.

2. *The road between Pichan and Barköl*

Sometimes the way lies across a stony path in a defile between steep hills. It is easier for the horses or mules to drag the cart where there is a solid road as in the photograph but the wooden wheels suffer badly on the stones, and broken axles or broken wheel rims are common accidents when such mountain passes have to be traversed.

3. *The Caves of the Thousand Buddhas*

The Caves of the Thousand Buddhas are hollowed in a conglomerate cliff south-west of the oasis of Tunhwang. In 1908 Sir Aurel Stein made a prolonged stay in the place and brought away many valuable manuscripts, paintings, and rolls of silk which are now in various museums. The great façade is pierced with numerous openings each one of which is the entrance to a temple or shrine. On the frontage of the caves there are many niches in which stand carved figures while the caves themselves are decorated with skilfully executed frescoes which often present the figure of the Buddha in some characteristic attitude.

4. *The tower of Sirkip*

The tower of Sirkip is a beautiful monument standing on the plain which gradually slopes downward to the Turfan depression. The foot of the terraced shrine measures 48 feet square, and the base on which it is built is 10½ feet high. Above the base are six terraces, each one a little narrower than the one below. The seventh terrace is largely destroyed; above it there was probably a superstructure which must have added a final touch of dignity to this classic tower.

5. *Mounds of loose silver sand*

The plains of Inner Mongolia are sparsely wooded with clumps of the desert poplar, tangles of tamarisk, and dry trunks of *saksaul*. When the dreaded *buran* blows, all of these arrest the drifting sand which piles up in mounds around their roots and finally smothers them in its close embrace. The dead wood feeds the traveller's camp fire, and the soda from the burnt-out ashes is used to raise the dough of the loaf which he cooks.

6. *A desert landmark*

This tower stands between the town of Tunhwang (Blazing Beacon) and the dunes which encircle the Lake of the Crescent Moon. The *tuns* or desert landmarks date back to an early period. On the summit is a platform which was used for fire-signalling; sometimes an inner passage still exists by means of

which the platform can be reached. No longer used as signal towers they still serve as guide for the traveller who directs his course by these monuments which can be seen from a great distance.

7. *The sand-hills of Tunhwang*

South of Tunhwang the sand is piled up into lofty dunes which change their contour according to the prevailing seasonal wind. Under the influence of the winter blizzards their summits curl over like the crest of a wave while the sand spray is tossed afar to fall again in light sand showers.

8. *Desert grass*

The desert grass grows to a height of 6–7 feet. Only when it is quite young and tender can it be used for horse or camel fodder; when the stems are tall and strong they serve for a number of domestic purposes. The desert dwellers cut the grass in early autumn, and during the winter they weave mats from it to support the mud roof of their houses, to cover the mud bed on which they sleep, to make bins for storing grain, and for many other purposes. Most of the articles of daily use in the oasis shacks have been woven, tied, or twisted from the strong stems of this grass which grows abundantly even under the most unpromising conditions.

9. *Talking with Mongols at their tent door*

On arrival at the door of the Mongol *yurt* it is customary for the visitor to approach with outstretched hands thus showing that he has no weapon for attack hidden up his sleeve. When once the Mongols are convinced that their visitor comes peaceably, the guest may be sure of a welcome and unlimited hospitality. The lecturer is seen here with her host and hostess.

10. *Inside a yurt*

The master of the *yurt* sits in his own place when entertaining guests. Etiquette requires that the visitor should sit with one knee erect, and this knee must be the one nearest the host. The small fire is coaxed into a flame, camel's milk is brought in, heated in an iron pot, and handed to the guests. These *yurts* are built up on a wooden framework and covered with felt.

11. *Oasis of Liaotung, squalid inns*

The smaller oases often lie in a low declivity, so that the roofs of the dwellings appear to be part of the desert outline; when seen from a distance they are difficult to pick out from their surroundings. Each oasis however has some distinctive character.

12. *The inn courtyard*

The courtyard of a camel inn is a place of great interest to travellers in Central Asia. As the caravan arrives the camels kneel in rows at equal distances from each other. Each man quickly unloads the beasts for which he is personally responsible and stacks the bales of merchandise so that they can be most easily replaced on the wooden pack-saddles. Then without delay the tired camels are led off to pasture, for it would be unnecessary expense to feed them in the inn. At any hour of day or night the camel trains arrive or leave on their long treks.

DISCUSSION

Before the paper the PRESIDENT (The Rt. Hon. Sir GEORGE CLERK) said: In accordance with our usual custom, we sent invitations to diplomatic representatives in this country and to members of the governments of the Allied Nations to attend this lecture, and these were cordially acknowledged. I will

only say that should there be any officers here who have come in consequence of that invitation they can be assured that they are most cordially welcome.

I come now to the lecturer of this evening. Many of you will remember with pleasure the Fifth Asia Lecture which Miss Mildred Cable delivered in March 1934—eight-and-a-half years ago. Her subject then was "The bazars of Tangut and the trade routes of Dzungaria." In that lecture she told us, incidentally, of her great discovery of a second Cave of the Thousand Buddhas, and she had also to mention more than one beautiful place that had been destroyed in the brigand warfare then raging. At Qomul, as she said, "this last remnant of Arabian-night conditions had gone for ever."

Miss Cable began her life's work for the China Inland Mission in 1901, and for the best part of forty years has observed the life of North-Western China as very few have been able to do. Since we heard her last the process of change in that life has been accelerated, and to-night she has called her subject "A new era in the Gobi." We are happy to see her again on our platform, and to welcome also to our meeting her friends, Miss Evangeline and Miss Francesca French, who have shared her labours, her journeys, and her triumphs.

Miss Cable then delivered the lecture printed above

The PRESIDENT: We have listened to a paper of extraordinary interest—a paper that has gone perhaps a little outside the scope of strict geographical interest, but I know you will all agree with me that it is none the worse for that. I will not take up your time in discussing the many interesting points that Miss Cable has raised. But I must comment on her facility for short vivid phrases which bring the picture before us so that, as she lectures, we actually see what it is that is happening. It was a short, but an admirable word picture. What struck me particularly was the casual way in which Miss Cable spoke of her adventures in the desert, as though she had been walking only through the English countryside. You would have thought that there were no hardships or dangers for her. We know that she was extremely welcome wherever she went, but a great deal of hardship must have been entailed, as will be apparent if one thinks what her journeyings must have meant. You will join with me, I am sure, in expressing our thanks for this lecture and also our admiration for the lecturer and her companions.

FORECASTING RUN-OFF FROM SNOW SURVEYS

CAPTAIN R. C. FARROW, R.C.A., Chief Hydraulic Engineer, Wate
Rights Branch, Province of British Columbia

Meeting of the Society, 9 November 1942

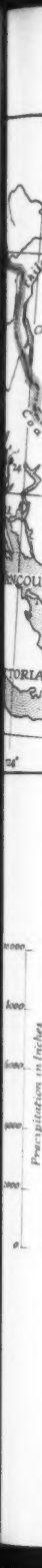
THE Rockies, forming the backbone of the North American Contine extend for some 5,500 miles from Alaska through Mexico. From th Rockies westward to the Pacific Coast a series of parallel ranges alternates wit intermontane valleys and high plateaus. Through Canada and Alaska th summit of the Rockies averages about 400 miles from the coast, but swin farther inland to the south. Along the Pacific Coast the land rises abrupt from the sea to form the great mountain barrier which is known as the Coa Range in British Columbia and the Cascades in the States of Washington an Northern Oregon; the range fades out in Southern Oregon. The Coa Range is more massive and contains higher peaks than the Canadian Rockie its highest peak, Mount Waddington 13,260 feet, being the highest in Britis Columbia.

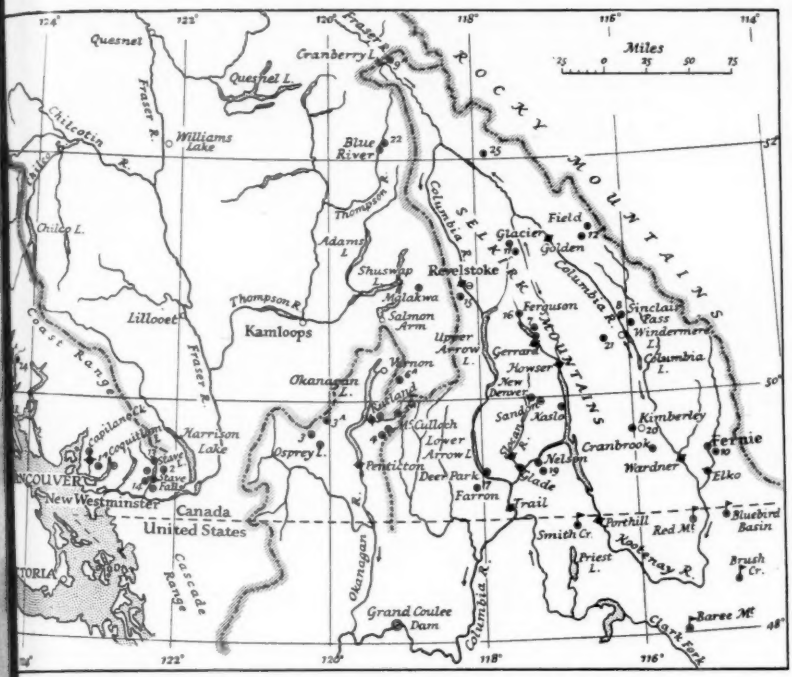
The successive mountain ranges have a profound effect on climate. T Pacific winds, warmed by the Japan Current, and laden with moisture, a forced upwards by each mountain range in turn. Each succeeding ran naturally receives less moisture than the one before (see Pl. 2). This well illustrated by the accumulation of snow at the end of winter, measur where drifting has not occurred. In the Coast Range depths up to 30 feet a found; in the Selkirk and Cariboo ranges 12 feet, while in the Rockies 3 fe is rarely exceeded.

A "dry belt" lies in the lee of each range and the most westerly one is t driest. Hugging the eastern flank of the Coast Range it extends southw from central British Columbia through the State of Washington and in Oregon. In the lee of the Cariboo, Selkirk, and Kootenay ranges lies the d Columbia–Kootenay Valley; while beyond the Rockies the western prair extend eastwards towards the Great Lakes.

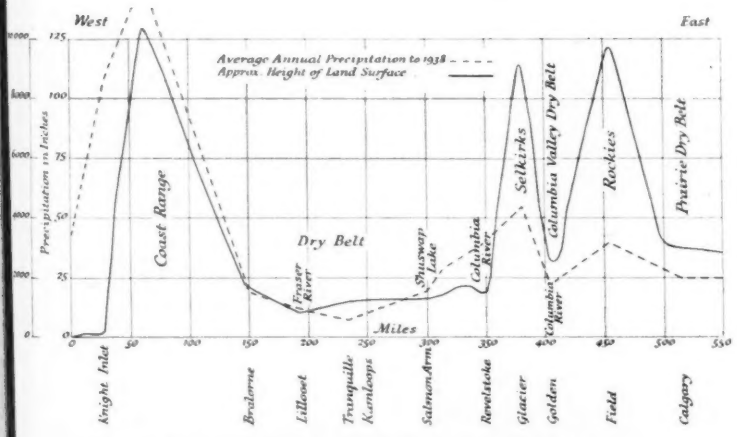
The lower slopes of each mountain range are clothed in valuable timb and the western slopes receiving the most moisture have the heaviest stan the Pacific slope of the Coast Range is noted for its giant douglas fir, ced and spruce. The valleys contain much fertile land, and farming, fr growing, stock raising, and dairying are successful. On the coast, where t climate is mild and somewhat like that of the south of England, mix farming and dairying is very similar to that carried on in this count In the interior Dry Belts however, of which the Okanagan valley is perh the best known, irrigation is necessary, which naturally raises the cost of p duction, so that crops are more specialized, fruit predominating. The gr heat and clear skies produce ideal growing conditions when water can brought to the land. The principal crops are apples, pears, plums, cher peaches, apricots, melons, tomatoes, onions, celery, and lettuces.

In the higher and rougher parts of the Dry Belts where the land is less s able for agriculture and general irrigation would be too costly, there are m


Precipitation in Inches



1. Snow Surveys in British Columbia



2. Diagram showing precipitation and altitude

Phot. H. O. Frind

3. Mount Burgess and Emerald Lake, Rockies

4. Near Snow Course 11 in Selkirks: good forest protection, 9 feet of snow

Phot. H. O. Frind

3. *Mount Burgess and Emerald Lake, Rockies*

4. *Near Snow Course 11 in Selkirks: good forest protection, 9 feet of snow*

tock ranches where some of the finest beef is raised. Many of these ranches re of considerable size. The Douglas Lake Ranch in the Nicola Valley is now he largest cattle ranch in Canada, running ten thousand head of cattle and me five hundred horses.

With an abundant precipitation on the mountain ranges British Columbia nd Washington are well served by streams of all sizes from mountain brooks great rivers, and numerous lakes, many of considerable size. It was evitable therefore that despite extensive coal measures, the mountain treams should become the major source of electric power; to-day large ydro-electric companies serve the various areas, providing electricity for omestic use in both urban and rural communities, and power for miscellane- us industries in the bigger cities, for the big pulp and paper mills on the ast, and the great metallurgical works which are fed by the mining industry; hile many isolated mills, mines, and industrial plants have developed their n primary power.

It was early recognized that the vast yearly accumulation of snow in the ountains was the principal reservoir which fed the streams throughout the ar. Summer and autumn rains are negligible in this connection, even on me parts of the coast, though the northern portion receives more than good easure. Hydrometric studies by engineers of the British Columbia Water ights Branch have shown that in British Columbia 85 per cent. of the run-off curs in the seven months March–September, and this is practically all ter from the melting snow-fields. This leaves only 15 per cent. of volume r the remaining five months. With advancing spring the melting snow ells the streams, the ice on the rivers of the interior breaks up—an awe- spiring sight as great slabs many feet in thickness crash and grind; now rming enormous jams only to break before the irresistible force of the ounting flood waters, and then go hurtling down through mountain gorges. rying slightly with locality the peak is reached some time in May or June d then the spring freshets gradually recede.

When the demand for water began to exceed the flow of the low months, rage had to be created to hold these flood waters, and storage reservoirs re generally made by damming the outlet of some of the many lakes which to be found on most of the drainage systems. The watersheds adjacent to dry belts have less natural lake storage than elsewhere; and purely ficial reservoirs often have to be made.

As snow is the primary source of most of the streamflow it is surprising t for so long no serious effort was made either accurately to measure snow terms of water or endeavour to assess even roughly the volume of water red in winter snow-fields. The ordinary rain-gauge is quite useless for asuring snowfall and the only measurement made until recently was that depth following each storm. The Meteorological Bureaus, both Canadian d American, use the rough assumption that 10 inches of snow is equivalent 1 inch of rainfall, or that the density of snow is 10 per cent. But snow is y variable in density. The density of newly fallen snow has been found to y between 15 per cent. and 18 per cent., and the accumulation on the und at the end of winter has in my experience varied from 19 per cent. to per cent., depending on type of snow, depth, and exposure to wind.

It was not until a young offspring of the Science of Hydrology was born that any scientific attempt was made to evaluate the water content of snow, or predict its effect on run-off. This offspring was christened Snow Surveys for want of a better name.

Research on snow began many years ago in Europe in the study of its density, but it is only in the past forty odd years that the practical application of this research has been developed. This development began with the mountains as a vast laboratory. In 1904 Dr. J. E. Church, then Meteorologist of the Nevada Agricultural Experiment Station, established an observatory on the 10,800-foot summit of Mount Rose, in the Sierra Nevada. Dr. Church became the founder of Snow Surveys and has been one of the leading figures, if not the leading figure, in their development. For many years he was Chairman of the Committee on the Hydrology of Snow of the American Geophysical Union. The writer had the honour and pleasure of serving on this committee under his able and tireless chairmanship, and shortly before being drawn into this war was elected his Vice-Chairman. Dr. Church has since been elected President of the Section of Hydrology of which the Committee on Snow is a part. He is also a member of the International Commission on Snow and Ice.

Mount Rose Observatory was established to study the effect of forests on the conservation of snow and all phases of the evolution of the snow pack; its creation, its melting, losses from evaporation, water content, etc. As research continued certain fundamental relationships began to emerge, were eagerly pursued and developed, and finally put to practical use. The Nevada method of Snow Surveys had come to stay.

In the meantime definite attempts to forecast run-off from snowfall were being made along different lines. By soundings of snow depth over surveyed cross-sections of certain basins an approximate estimate of the cubic contents of the snow was made; this was converted into the equivalent volume of water. The method however was obviously far too laborious and costly for anything but the smallest of basins.

In its infancy snow surveying had to face the scepticism which greets new theories and new methods. But isolated successes in forecasting began to attract attention, and in the arid south-western States where water is the life-blood of the country the possibility of estimating ahead of time what volume of water would be available, was eagerly seized upon. Various organizations established snow-survey systems, such as irrigation districts, power companies, and State Departments of Water Resources. Now a vast international network has been built up embracing southern British Columbia and Alberta in Canada and the American States of Washington, Idaho, Montana, Oregon, Wyoming, California, Nevada, Utah, and New Mexico. Alberta and British Columbia were the latest recruits, joining their American Cousins in 1937. Drainage areas recognize no political boundaries, and the 49th parallel cuts across river systems and lakes with impartiality. Those of us who pioneered snow surveying in Canada owe much indeed to the help and guidance and cooperation, even loan of equipment, extended by our American colleagues.

This vast network of interlocking systems embraces an empire in itself with

an area approximately equal to that of Continental Europe less Russia, Norway, and Swe[illegible] The Columbia river basin system in British Columbia alone covers 50,000 [illegible] uare miles, an area equal to that of England.

The pioneer med[illegible]n for formal cooperation and standardization was an organization known as the Western Interstate Snow Survey Conference, which still functio[illegible]. In 1934 the United States Department of Agriculture undertook the task of formal coordination and direction, and now receives and tabulates all data, issues and distributes new snow-sampling equipment, and provides for systematic expansion. For fostering scientific research into the various problems which arose, the American Geophysical Union, a Committee of the National Research Council, formed a Committee on the Hydrology of Snow as a part of its Section of Hydrology.

The conservation and loss of snow

Research indicates that forests conserve snow by protecting it from the sun's rays and from wind. Their effectiveness in gathering and retaining it is most marked when compared with bare open slopes. At Mount Rose Observatory, Dr. Church's observations disclosed the following conditions at the end of the snowfall season; the whole area under observation having received the same snowfall. Depth of snow is in inches, and the figures in brackets give the water content in inches. "Unforested talus slopes 40·8 (18·4), distributed thus; cornice below observatory 52·5 (25·1); windswept slope 8·1 (2·6); protected slope 78·1 (35·1). Forested slope 88·6 (41·1)" (*Geogr. Rev.* 23 (1933)). The conserving effect of forests appears to far outweigh the losses due to interception, plant use, and transpiration.

On the other hand, despite the heavy snowfall, the higher elevations of our mountains, above timber-line, appear to produce very little run-off. Most of the snow is apparently lost in evaporation both in winter and summer. High winds blow almost constantly about the bare peaks and undoubtedly induce a high rate of evaporation even at sub-zero temperatures.

Dr. Church examined this loss at Mount Rose Observatory, and found that evaporation increased roughly as the wind velocity. On the leeward slope under an average wind velocity of 10·8 m.p.h. evaporation amounted to 7·17 inches of water per month; while on the windward slope with an average wind velocity of 30·6 m.p.h. evaporation was 24·21 inches. At velocities above 30 m.p.h. erosion began to take place, forming cornices and drifting the snow into ravines and crevasses.

In summer evaporation is increased by the warmth of the sun. Solar rays are very intense in the clear air at high altitudes, and solar radiation is greatly magnified at the snow surface. With the low humidity and high winds to keep the air in motion, conditions are ideal for evaporation. Whilst engaged on work above timber-line in the spring and summer the writer came to the conclusion that very little run-off occurred from the high snowfields; only the merest trickles of water flowed from the fringes of the snow-fields even on the hottest days. Their annual dissipation therefore appeared to be largely due to evaporation.

This conclusion was substantiated by the work of Mr. François E. Matthes of the U.S. Geological Survey and Chairman of the Committee on

Glaciers, American Geophysical Union, who in 1937 made an exhaustive examination of snow losses at high altitudes. In a comprehensive paper he laid his findings before the Western Regional Meeting of the American Geophysical Union in January 1938 (*Trans. Amer. geophys. Un.*, 1938). His opinion supported by a mass of data, sketches, and photographs, was that very little water found its way to the streams from this source, and that the yearly dissipation was largely due to evaporation.

Fundamental relationships

From the research at Mount Rose Observatory certain fundamental facts became apparent. It was a fortunate chance that an area happened to be chosen where the influence of distorting factors, which might have obscured the general relationships, was negligible.

These relationships upon which the Nevada, or percentage method of Snow Surveys is based, are as follows: First: That over a given basin the relative water content of the snow cover is the same wherever measured, provided neither drifting nor melting has taken place. That is, if the water content at some point is found to be, say, 75 per cent. of normal, it would also be 75 per cent. of normal at other points in the same basin within a very small margin of error, regardless of the actual depth of snow. Second: That the percentage of normal of water content of the snow-pack at the end of the snowfall season agrees closely with the percentage of normal streamflow to be expected from the basin during the ensuing run-off months.

While the first relationship refers to a basin in its narrowest sense, the area which actually feeds a single stream, it frequently holds good over extensive areas embracing the many such small basins that go to make up the watershed of a large river. It may even hold good over separate but contiguous watersheds.

Distorting factors

The relationship between the water content of snow, when measured, and the run-off therefrom may be distorted by certain factors. Only two are at present recognized as of sufficient magnitude seriously to affect the accuracy of forecasts. These are: Precipitation during run-off, and the Soil Priming Factor. While artificial streamflow regulation is important, it can be allowed for by reducing the flow data to terms of unregulated flow from the records of storage and outflow.

Precipitation falling during the run-off period and subsequent to measurement of snow-water content may disturb the normal relationship between water content and run-off by the amount of the unmeasured increment which it adds to the latter. A normal relationship is therefore dependent on normal precipitation during run-off. In general the magnitude of its effect is influenced principally by the ratio of spring rains to winter snowfall. If the ratio is small the effect, even of abnormal precipitation, will be negligible; if the ratio is large an abnormal precipitation may so distort the snow run-off relationship that forecasts within acceptable limits of error are impossible.

Fortunately, even if a study of past precipitation records indicates that there will be a serious distorting factor it is often found that compensating

circumstances have neutralized it. This is especially so in mountainous areas, probably for the following reasons. Most precipitation stations are located in the valleys, so that local residents can act as observers, where the proportion of summer rains to winter snows is much greater than at the higher elevations which produce most of the run-off. Also, summer rains, while often intense, are much more local in occurrence than the winter storms which produce the snowfall.

If spring and summer temperatures are high, and relative humidity low, the rain, falling on increasingly large areas of snow-free ground, is largely taken up by evaporation, soil absorption, plant use, and transpiration, leaving little if any to accrue as run-off. As for instance in the Canadian Columbia basin where studies indicated that precipitation during run-off might distort the snowfall run-off ratio, but such was not the case [1] (see Pl. 1).

If the soil is dry beneath the snow when thawing begins a certain proportion of the melting snow will be required to re-prime the soil before there is any run-off, and this represents a loss to streamflow. The writer has termed this the Soil Priming Factor. Its presence and magnitude depends upon the type, structure, and depth of the pervious earth mantle, and on the amount and annual variation in autumn rainfall. In arid regions such as Utah and Nevada the snow falls upon dry soil in most years, and as a consequence only some 50 per cent. of the snow-cover reaches the streams as run-off.

Dean G. D. Clyde, of Utah State Agricultural College, who has fathered Snow Surveys in that State, amongst other valuable contributions to technique, has devised a method of testing for soil moisture content by borings made at the same time as the snow sampling. Water content is then weighted for the soil priming factor.

In the semi-arid Okanagan Basin of British Columbia deep deposits of alluvials and glacial detritus are capable of holding an immense amount of water in storage. Here the soil priming factor can, and often does, exert a marked influence on the snow run-off ratio. As the cost of necessary equipment and skilled personnel prevented the adoption of Dean Clyde's direct method, the writer made a study to determine the relationship, if any, between pre-snow rainfall and the soil priming factor. The rainfalls of suitable precipitation stations were chosen by trial and error for various autumn periods just preceding permanent snowfall and were compared with the disparity between snow water content, as obtained from precipitation records, and recorded run-off of the Okanagan river. Even with the known inaccuracy of deducing water content from precipitation records of snowfall it was evident that a relationship existed. A correction curve was then developed from which a coefficient could be obtained each year and applied to snow water content. This method produced results in several years of forecasts, and as years of snow-survey data are built up to replace the past precipitation data it is believed that it may provide a reliable correction. Unfortunately, studies were cut short by the war.

In rough mountainous country such as the Canadian Columbia and

[1] R. C. Farrow, "Snowfall and run-off in the Canadian Columbia basin; a study to determine the ideal location for Snow Survey Stations," *Trans. Amer. geophys. Un.*, 1937, pp. 632–44.

Kootenay river basins this factor is either negligible or relatively constant from year to year, and has no noticeable effect on run-off. This is probably partly due to the steepness of the ground and shallow earth mantle and partly to a sufficiency of autumn rains even in minimum years to prime the soil.

The technique of snow surveys

A snow course is a permanently established line of fixed points at which depth and water content are measured each year usually about the end of March, April, and perhaps May. In the pioneer days of snow surveying long courses of as many as sixty observation points were used. Experience has shown however that ten to fifteen points 100 feet or so apart are quite sufficient.

Having decided on the general location of courses a reconnaissance should be made in both winter and summer if possible, before definite sites are chosen. The courses are laid out and the observation points marked by stakes high enough always to show above the snow. In order to replace them should they be destroyed, they are referenced to nearby trees or rock surfaces, by affixing red metal plates painted with the number of the observation point and the distance to it. The site should be below timber-line but high enough to be free from premature melting, protected from drifting, and shaded to some extent from the direct rays of the sun. Winter reconnaissance is desirable because sites that appear feasible to reach in summer may be out of the question in winter. Approaches involving rock climbing should be avoided for winter travel. Areas subject to avalanches are not always recognizable as such in summer.

Many courses cannot be reached from the nearest habitation in a day's round trip, in which case a log cabin has to be built to accommodate the snow-sampling crews. Furnished with the usual primitive bunks, a table and stools, small stove and cooking utensils, it is left well stocked with firewood and a locked metal chest containing suitable non-perishable food. Maintenance crews visit the sites each year, keep the brush cleared about the sampling points, re-establish any missing points, and re-stock the cabin with wood and supplies.

A special problem in shelter cabins arose in the Coast and Cascade ranges; the enormous depth of snow would completely cover a cabin, so that it could neither be easily found nor entered when found. They are therefore built with a high tower at one end, a door in the top of the tower, and a ladder inside for descending into the cabin below.

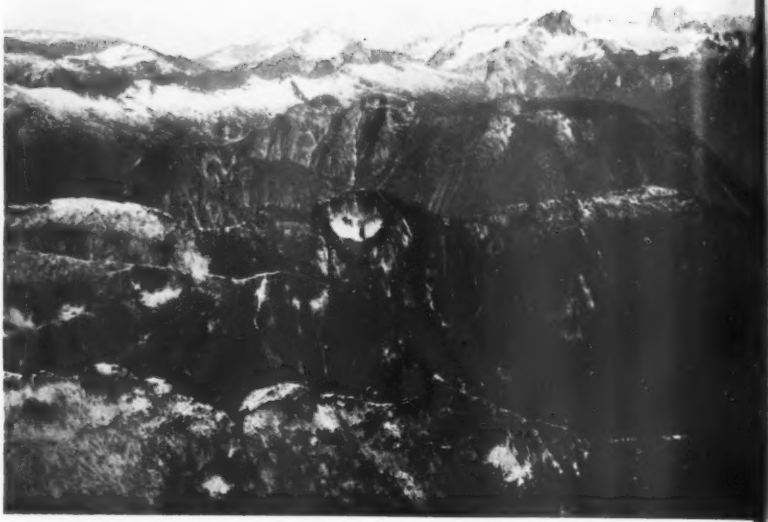
Snow survey equipment in general use and standard in the Western Cooperative Surveys consists of aluminium alloy tubes, in about 30-inch sections which can be screwed together to make up any desired length (see Pl. 8). In the Coast Range and Cascades up to 25 feet of snow has to be provided for. The tubes are slightly over $1\frac{1}{2}$ inch diameter and slotted so that the rise of the snow core can be noted, they are graduated in inches for measuring depth. The bottom section in each set is equipped with a saw-toothed cutter for boring through ice and crusts. The cutter contains a throat of such diameter that a cylinder of snow core weighing 1 ounce will be equivalent to 1 inch of water content. A spring balance and a cradle are provided for weighing the tube and core. A form of wrench can be fitted to the

5. Rogers Pass, Selkirk Range, as seen from Snow Course 11

6. Snow Course in the Coast Range, an ideal location: 19 feet of snow

Sampling on the Okanagan water-
ed

8. Snow sampling tube and scale



9. Looking north-east across Coast Range near Vancouver

10. Looking east across Coast Range: snow largely dissipated by evaporati

tube to assist in forcing it down through hard snow. Observations are recorded in standard field books.

Snow sampling is the operation of determining the depth and water content of the snow. Periodical samplings throughout the winter are used for studying the evolution of the snow-pack and also for preliminary forecasts where very close regulation of reservoirs is necessary. Sampling for the main forecast is usually done about the end of March, the exact time varying with locality. Further samplings in April and May provide a check on precipitation during run-off and enable forecasts to be revised if necessary. In sampling, the tube is forced down through the snow at each observation point so that a core of snow, equal in diameter to the cutter throat, rises in the tube, the depth is noted, and the tube withdrawn with the snow core inside it; the difference in weight between the empty tube and tube with snow core represents the water content in inches. The average for all observation points is the water content for the course.

The work is carried out on snowshoes or skis, usually the latter, except where the approach is very rough or very brushy, and sometimes involves long trips of several days and always a stiff climb of anything up to 5000 feet. If lucky it is an exhilarating trip through woods and mountains, beautiful in their winter garb, stiff climbs alternating with long breath-taking ski runs. But if the weather is bad, the small party flounders through newly fallen powder snow or slogs over a surface sodden from an unexpected thaw or bucks head down into a blizzard, it can become a sheer heart-breaking grind, in which miles seem like leagues, and each wearily takes turns at breaking trail, and at the trail's end rolls into a sleeping-bag and sleeps the sleep of exhaustion. In some cases, when available, dog teams are used, otherwise each man has to carry a pack of about 30 lbs.

Developing a snow-survey system

While the fundamentals of snow surveying are simple many complex problems arise in actual practice. A thorough study of all available data is essential before attempting to lay out a system; topography and general geology studied; precipitation and streamflow records should be carefully analysed in order to detect the presence of any relationship between the two. Given a number of precipitation stations on a watershed even if the data from individual stations bears no particular relationship to streamflow, it may be possible to co-relate a combination of all or of some with run-off. It involves much tedious statistical analysis—trying one combination after another. Once a combination with a good run-off relationship is found, it furnishes a valuable guide for the siting of snow courses; if they are in the same areas as the precipitation stations and their data combined in the same way they should yield accurate forecasts. It is the only way in which a minimum number of snow courses can be made to serve large areas.

This method was used by the writer in laying out the Kootenay and Columbia systems (*Trans. Amer. geophys. Un.*, 1937, pp. 632–44). As a result twenty-three courses, eighteen Canadian plus five adjacent U.S.A. courses, serve the Columbia basin as far as the International Boundary—an area of some 50,000 square miles.

From the standpoint of forecasting, different regions and conditions present their own particular problems, and while the fundamental relationship remains the same, the various distorting factors influence the method of approach.

A preliminary normal of water content can be established by using the computed normal of run-off at the co-related stream gauging station, or by using the normal of snowfall at an adjacent precipitation station, when analysis has shown that its data will co-relate with run-off. When neither run-off nor precipitation data are available, a number of years must elapse before an independent normal of water content can be built up from snow-survey data.

Usually several snow courses are related to a single stream gauging station. This may be done in two ways according to the indications of prior studies. Each course may be assigned a zone, or partial area, of the watershed concerned, and an average for the whole arrived at by combining the water content of all, each being weighted according to the size of its zone. A secondary weighting by altitude zones is also sometimes necessary, where there is danger of premature melting on some courses; this method is used with the British Columbia Okanagan course. Or when each course represents a large area, and their location has been based on precipitation run-off studies, the average of their percentages of normal can usually be used for forecasting; this method is used in British Columbia for the Kootenay and Columbia river forecasts.

Correction for the soil priming factor may be necessary; and in areas where precipitation during run-off is a factor, forecasts may have to be revised each month if the factor departs from normal.

Forecasts for major streams with established stream gauging stations are made in acre feet covering a given period, usually April 1–August 31. For smaller streams and streams having meagre or no streamflow records at all, the forecast is in per cent. of normal or per cent. of the previous years' flow.

Under the nevada or percentage method of forecasting all computations of snow water content, both for individual snow courses and for basins, are made in percentage of normal. These computations consist of first combining the water content of individual courses, each appropriately weighted if necessary for area and altitude zone. The percentage of normal so deduced is then weighted for the soil priming factor if necessary; finally in accordance with the second fundamental relationship (defined on p. 210) it is multiplied by the known normal of run-off in acre feet at the appropriate corelated stream gauging station. The result is the forecast in acre feet. The computation thus only becomes quantitative in the final step.

Accuracy

It is usually considered that forecasts within a limit of error of 10 per cent. are of value, but in most established snow surveys accuracies within 2–5 per cent. are becoming common, and accuracy increases as records build up and distorting factors are studied and allowed for.

Unfortunately the writer has no data at hand on results achieved subsequent

to 1937. The accuracy attained at that time on the Kootenay–Columbia Systems in British Columbia, still in their infancy, are as follows:

River		Per cent. of normal R.O. forecast	Forecast R.O.	Measured R.O.	Error 1937	Error 1936
Columbia	at Golden	74·1%	1,551,000 ac. ft.	1,529,000 ac. ft.	1·4%	11·5%
	Revelstoke	75·7	13,237,000	13,077,000	1·2	*
	Trail	77·8	27,798,000	28,414,000	2·2	*
Kootenay	at Wardner	79·9	2,997,800	2,804,700	6·9	5·8
	Glade	79·6	11,721,400	11,781,000	0·5	*
Elk	at Elko	79·6	873,300	816,300	7·0	*
Lardeau	at Gerrard	74·9	394,000	379,000	4·0	7·9
Duncan	at Houser	74·3	1,311,000	1,404,000	6·6	6·8
Okanagan	at Penticton	101·6	305,400	328,400	7·0	7·8

* No forecast in 1936.

In Idaho snow surveys have reached such a degree of reliability, and command such public confidence, that water for irrigation is allotted to users on the basis of snow-survey forecasts long before the snow has melted and reached the streams which will later feed the irrigation canals. This enables the farmer to plan his cropping well in advance and with the assurance that a definite amount of water will be available.

Measurement of streamflow

Reliable year-to-year records of streamflow are essential in a country where water plays such a large part in the economic life of the people. While not a part of snow-surveys stream measurement is so closely related to them that a brief description of hydrometric technique as developed on the North American Continent may be of interest. The controlling and harnessing of rivers of great size demands streamflow data of a high order of accuracy and often heroic measures to obtain them.

On account of varying demands for the measurement of flowing water for different purposes and all degrees of accuracy, various methods have been devised, each more or less suited to its particular purpose. Methods in common use can be divided into two general classes each with several different mechanical means of measurement.

The two general methods are the velocity area and the direct discharge. Discussion of all methods is outside the scope of this paper; it is with one of the velocity-area methods that we are concerned. In all velocity-area methods the mean velocity of the flowing water and the cross-sectional area of the channel are determined, the product of the two giving the discharge.

Two units of measurement are used in basic hydrometric data for large streams. The acre-foot as a unit of volume, and the cubic-foot per second (c.f.s.) as a measure of velocity. The two inter-relate very conveniently for calculations involving storage, as 1 c.f.s. flowing for twenty-four hours will accumulate 2 acre-feet of water (with an error of less than 1 per cent.). An acre-foot is a volume 1 acre in extent and 1 foot in depth.

The current meter is preferred for measuring water in open channels and is almost exclusively used for rivers. This little instrument is essentially a delicately balanced propeller which revolves in response to the slightest current; vanes keep it headed directly into the current, and torpedo-shaped

weights of varying size can be attached to sink the meter vertically. Its revolutions are transmitted electrically to the operator, who converts them to velocity in feet per second. They are accurately rated and the rating frequently checked.

A permanent stream-gauging section on a river has to be chosen with great care, and much depends on the judgment and experience of the locating engineer. The site should be one where changes in stream-bed profile are negligible and the current moderate. A bed-rock channel is ideal provided there is not too much turbulence. On very large rivers a bridge is best for taking measurements from, provided the section is suitable; otherwise a cable-way is installed, along which a suspended car can be moved by hand; or a boat may be used, attached to the cable by a travelling bridle.

An accurate cross-section of the channel is obtained and permanently referenced on either bank. Permanent points of measurement along the cross-section are then established and marked on the bridge or cable or sometimes along a special line stretched across the river. The measuring points are established where abrupt changes of velocity and bottom profile occur but not more than 5–10 feet apart. If there are no abrupt changes they are evenly spaced at 5 or 10 feet according to the width of the section.

A gauge is established in close proximity to the section. On important streams, in order to maintain a continuous record, automatic stage recorders are installed. The Stevens type is favoured by the Water Resources Branch of the U.S. Geological Survey and Canadian Water and Power Bureau. The instruments are very precise and will maintain a continuous record for six months without attention, though as a rule they are visited monthly in summer and once or twice in winter depending on importance and accessibility.

A continuous trace of the rise and fall of the stream is recorded against time, on graphical paper subdivided to tenths in one direction for gauge heights and in twelfths in the other direction for time. The graph looks not unlike that recorded by a barograph. The time mechanism is controlled by a chronometer and the gauge height mechanism is actuated by a float rising and falling in a well beneath the gauge house. The recorder is housed in a small building of standard design sited well back on the bank with a well excavated beneath it. The well is connected with the stream by a horizontal pipe laid several feet below low-water level. Building, well, and intake are thoroughly insulated to insure operation during sub-zero weather. The well and connecting pipe damp out small surface fluctuations due to current surges and wind.

Current meter measurements are made at each point at such depths that a mean velocity in the vertical is obtained. From the study of vertical velocity curves, depths of measurement to obtain a true mean velocity have been determined with a resultant average error of zero and a maximum error of 1 per cent. Having the mean velocity and the depth at each measuring point, the mean velocity and mean depth between each adjacent pair of points can be computed, and the product of these two factors gives the discharge for that segment of the cross-section. The sum of the discharges of all segments gives the total discharge in cubic feet per second.

When a new gauging station is set up current meter measurements are

made at frequent intervals through all stages from low to high water and the corresponding gauge heights noted. The discharges thus obtained are plotted against the gauge height, producing a rating curve. Once the section is "rated" the discharge can be read off the curve for any gauge height recorded on the stage recorder graph.

The gauging stations are visited at regular intervals by engineers of the service, who meter the streams to see that the rating has not changed, check the soundings for change in profile, collect the graphical gauge record traced since the last visit, reset the gauge, re-wind the chronometer, and generally service it. In setting the gauge the recorder is adjusted to read the exact time and gauge height at the moment and both are noted on the graph.

The flow of a stream under ice conditions differs from its open water flow. The ice cover creates friction at the water's surface, while anchor ice on the bottom may reduce friction and thus increase velocity. The net result is a change in the vertical velocity curve. For streams that freeze over, winter measurements are taken and a separate "ice condition" rating curve is developed.

Obtaining a series of winter current meter measurements is a miserable job physically but often exciting. The writer remembers only too well working out in temperatures down to 50° below zero (82° of frost) in imminent danger of freezing extremities; cutting holes through 2 feet of ice at each measuring point, and keeping the hole clear of ice whilst metering. In the spring as the time approaches for the ice to go out there is the danger of being caught on the ice when the break-up starts. At such times each member of the crew has a stout rope secured about his waist to haul him up to safety should the ice go out beneath his feet. There are many scares and alarms; deafening detonations occur as the great ice-sheet cracks under the pressure of the rising waters beneath; cracks appear, and water oozes up; the surface heaves in an alarming manner.

On streams which produce dangerous floods, such as the Ohio and Mississippi, these gauges are tied into the Flood Control and Warning Service, and a further refinement is added. An ingenious device, also developed by Mr. Stevens, designer of the recorder, automatically communicates by telephone signal the gauge height for any desired unit of rise (usually every 6 inches or 1 foot) as soon as the river approaches a critical stage, and continues to report until the water-level recedes again to the same level. Another design has been worked out and I believe is now in operation which automatically "reports" by wireless. These are for remote areas having no telephone connections. The Flood Control headquarters is thus a nerve centre receiving constant reports from dozens of gauging stations on the main and tributary streams and thus having early warning of approaching flood conditions, and the progress of the flood-wave.

Many of the rivers are of great size and present individual problems of installation and maintenance. For instance the Fraser River (British Columbia) at Prince George, 450 miles from its mouth, is a little over half a mile wide and averages 12 feet in depth with a fairly swift current. In the great Fraser Canyon, where the river breaks through the Coast Range, it boils and swirls 100 feet deep between rock walls less than an eighth of a mile apart. The

Columbia river where it crosses from Canada into the U.S.A. is three-quarters of a mile wide and its average flow from April 1 to August 31 is 121,000 c.f.s., so that its peak reaches 600,000 c.f.s. in some years.

The strategic site for a gauging section is often in parts remote from any settlement, involving long trips with saddle and pack horses, sometimes by boat or canoe, and in winter on snow-shoes or skis with or without dog teams. A typical example was the installation of a permanent gauging station on a fair-sized river, having an average flow of about 2000 c.f.s. It was in a remote unsettled region, where the river debouched from the eastern flank of the Coast Range. To reach it there was a journey of 165 miles by car from the nearest railway over a road which gradually degenerated into a pioneer wagon trail; then a 100-mile trip by pack and saddle horse over an Indian trail. Cables, clips, bolts, etc., for the cable-way, lumber for the stage recorder house, nails and other builders' hardware, insulating material, blocks and tackle, shovels, picks, and miscellaneous tools, and blasting material all had to be transported to the job, as well as the crew with necessary tents and stores. The cable was too heavy for any one horse, so had to be taken in in sections and then spliced into one on the job. The station took a month to build.

Once the tented camp was established, a raft was made for crossing the river. With this a light pilot-cable was stretched across the river between two trees. The raft then operated as a ferry, attached to the pilot-cable by a travelling bridle, the current supplying the motive power.

The main cable towers were built of logs cut on the job. The main cable was run across on the pilot cable and stretched taut with an improvized Spanish windlass. Lumber for the car, the frame of the gauge house and for sheathing the well were hewn on the job. A log cabin was built for the use of the engineers who would maintain it year in year out on their rounds. Two bunks, a rough table, two stools, and a few shelves all of hewn lumber, plus a little iron stove completed its simple furnishings. We left behind a good pile of firewood and a set of pots and pans and dishes. Finally the automatic stage recorder was installed and set going; the river given a final metering, and late in the fall, in glorious Indian summer weather of warm sunny days and frosty nights, we headed back for civilization through the gorgeous colouring of the autumn woods.

Food supplies on such trips are of the simplest. Weight being of prime consideration, dehydrated vegetables, fruit, and milk are carried. Gun and rod supply meat and fish. In this instance deer, moose, game birds, and rainbow trout were abundant.

DISCUSSION

Before the paper the PRESIDENT (The Rt. Hon. Sir GEORGE CLERK) said: The lecturer this afternoon, Captain R. C. Farrow, Royal Canadian Artillery, is responsible in British Columbia for a very important service, the survey of snow and the gauging of streams by elaborate physical methods in order to predict the contribution of each season's snowfall to the run-off in the rivers. British Columbia and the United States bordering on the Pacific have between them built up a service which is of great practical as well as scientific importance, and

they work in an admirable spirit of cooperation and, if I may say so, friendly rivalry. The head of the American service, Dr. Church, is the Chairman of the Committee on Hydrology of Snow, American Geophysical Union, and our lecturer is the Vice-Chairman. The developments in snow survey which he will describe this afternoon should interest the scientific service of many parts of the world.

Captain Farrow then read the paper printed above, and a discussion followed

The PRESIDENT: I think Mr. Seligman is with us this afternoon. I do not know whether he would care to make any observations on the most interesting paper to which we have just listened?

Mr. SELIGMAN: We derive but few advantages from the war. One of them is that it thrusts up amongst us authorities from all over the world who are able to come here and discourse on their own special subject. We are most grateful to Captain Farrow for having told us of the extraordinarily adept way in which those concerned have adjusted themselves to the difficulties of the new art of snow surveying. It is a pioneer achievement of great magnitude. The difficulties and physical hardships which Captain Farrow has, I think, rather underestimated, have been enormous, and it is a matter for congratulation that he and his colleagues have achieved such great efficiency and also that they have joined up with the United States in making this a single task. You will remember that Captain Farrow mentioned the difference in snow accumulation on the Coast Range and on the Rockies, and said it was of the order of ten times as great on the Coast Range. I should like to know at what altitude that was. It will no doubt be different at different altitudes.

Captain FARROW: On the Coast Range the heavy snow accumulation commences at about 4000 feet and varies slightly with latitude. On the Coast Range at an elevation of 6000 feet there are literally 30 feet of snow over large areas, and in many of the passes 25 feet. I have never ventured on top of the glaciers in mid-winter, so that I cannot say what accumulates there, but up to about 7000 feet there is generally 25 feet of snow. The corresponding elevation in the Rockies where the accumulation would be only one-tenth of that in the Coast Range is about 6000–7000 feet. That however is a broad generalization. There are wide variations.

Mr. SELIGMAN: We were shown a picture of the new type of snow gauge which was being tested in the United States. Before the curtain was drawn over what the Swiss were doing in 1939 they were experimenting very actively with a number of snow gauges, and it might be of interest to Captain Farrow, unless he has already been in touch with the Swiss Meteorological Office, to ascertain what their latest investigations have shown.

Coming to the technical aspect of the matter, Captain Farrow showed us the snow sampler which Dr. Church has perfected, in which there is a cutting edge to drive down into the snow in order to bring the core of snow up into the cutter. A few years ago I was doing some work in which I also required a core of snow for an entirely different purpose. I was in touch with Dr. Church at the time and tried to use his cutter but found it quite hopeless from my point of view. I would very much like to know whether that cutter has given maximum efficiency. For my own work, from which it does not at all follow that it would be any help to this work, I used a cutter with a very sharp edge and saw-teeth, with alternate teeth turned in and out as on an ordinary saw. Is Dr. Church's cutter quite efficient?

Captain FARROW: Quite efficient for our purpose, but I can imagine it would not be very efficient for cutting ice. It would cut through semi-ice, a condition

sometimes seen where the snow has melted and frozen again. In order to drive the cutter down we have a wrench of sorts which we are able to clamp on to the tube. It is usually a process of putting the wrench on, standing on it with both feet, and pushing it down. I doubt whether the cutter would be very effective in ice, if that is what Mr. Seligman was using it for.

Mr. SELIGMAN: No, I was using it on advanced firn snow.

Captain FARROW: The only reason we do not want to turn a flange in on the inside is because of the diameter.

Mr. SELIGMAN: I have one more question which is not so much a matter of detail, on the subject of evaporation. I must join issue with Dr. Church's findings. If I have understood Captain Farrow correctly he says that snow evaporation is in direct proportion to the wind velocity. Really there are one or two other factors that ought to be taken into consideration. First of all, the humidity of the air. It follows that if the relative humidity is 100 per cent. the air cannot take up any more water and you will get no evaporation. Conversely, if you have a humidity of, say, 40 per cent. the air will take up water in large quantities, wind or no wind.

Then there is the question of the size of the snow particles; as snow gets older the particles grow in size. New snow has minute particles which expose a very large surface to any wind blowing through or over them and are far more sensitive to the evaporative powers of the air than old snow which might consist of crystals as large as grains of corn, or even larger, which would not only expose less surface but would possess a lower surface tension. I would like to know what Captain Farrow's reaction is to these points.

Finally, I come to the amazing accuracy with which the forecast has been made. That is to me most surprising. On the data we have had it seems almost inconceivable that such accuracy can be reached.

These are all the points I wish to raise. Again I thank Captain Farrow very much for his very valuable lecture.

The PRESIDENT: We have also with us Captain McClean, who has done much observation on stream discharge. Perhaps he would like to add a few words.

Captain W. N. MCCLEAN: I would like to say what great pleasure I have had in listening, particularly to the account of the river-flow gauging that has taken place; and to know that there is a state organization which can deal adequately with these surveys. In Scotland, my own small organization has measured the flow and maintained the records on seven rivers in much the same way and with similar apparatus. In this country we have not as yet a state organization for carrying out this work, although there is considerable pressure to bring that about.

I should like to add a word as to the measurement of snow cover in the West Highlands of Scotland. It is important from the water-power point of view because the snow and ice which collects on the mountains in the winter runs off just when it is required to modify the effects of the droughts of spring. In recent years, which have been as dry as those of the 80's, the dry periods of the spring have been somewhat similar. The depletion of reservoirs would be much lessened by the melting of snow and ice.

I have set up a recording water-level gauge on Loch Quoich, on the Inverness-shire Garry. The records go back to 1933. The Loch is $2\frac{3}{4}$ square miles in area and drains an area eighteen times that size. From these records the rate of change in content of the Loch permits quite a good estimate to be made of the run-off. The measurement of rainfall and snowfall is not equally good; but a relative figure can be obtained from one well-kept gauge. It is interesting to observe that there is a loss of run-off during the winter months, which is made

good from March to May or even June. It looks to me as if about 2 or 3 inches was a rough measure of the snow and ice storage which returned to swell the flows of spring. That would represent about 10 per cent. of the reservoir capacity required for a suitable water-power scheme for the area.

The snow and ice cover of the Scottish Highlands could not be measured as in Canada, because of alternate frost and thaw. The comparison of rainfall and run-off appears to be the only way. We have good reasons to develop those measurements, although irrigation is not one of them.

Captain FARROW: In reply to the points raised by Mr. Seligman, I touched quite sketchily on the matter of evaporation at high altitudes. It is one of the most important factors. On Mount Rose it was very low, and that would be true of the greater part of the Rockies and the Selkirks. The relative humidity is low and there is a high wind blowing all the time, so that there is a perfect condition for a high evaporation rate.

Another point Mr. Seligman raised was as to accuracy. You cannot expect to make snow surveys a success if the distorting factors are the predominant factors. We therefore went into areas where snow surveys were wanted and where we hoped and thought we would succeed. There were other areas on the coast where we had been 30–40 per cent. out. Predominance of summer rain so far outweights run-off of snow as completely to obscure the relationship even in good years; and even in good areas many freak years will occur to destroy the relationship. One of the most successful forecasts I know of is one of the earliest, in Idaho, which was referred to in the lecture.

Mr. W. L. SCLATER: The President asked me to take his place because he had to leave. Is there any one else who would like to ask a question? If not, it only remains for me to thank our lecturer for a most interesting lecture on his very important subject, more important in Western America than here. I know when I lived in Western America it always astonished me at Colorado Springs to see that when we had a snow storm the snow did not thaw in the way it does in England. Generally, they were very heavy snowfalls, but after the storms were over out came the sun and the air being very dry the snow just disappeared.

I am sure we all join in thanking our lecturer for his very entertaining discourse.

Mr. Seligman contributes the following additional notes

At the Meeting I expressed surprise at the extraordinary accuracy obtained in the forecasts; Captain Farrow in his reply said that high accuracy was not invariably reached and that some forecasts showed errors of 30–45 per cent.

In the course of his lecture I understood Captain Farrow to make two statements which seemed to entail rather bold assumptions: first that in a given basin the snow was assumed to possess uniform relative water content throughout, and secondly that this was regardless of the depth of snow. I think that these assumptions ignore the fact that the specific gravity of a snow cover is largely influenced by its orientation to wind and sun as well as by other lesser factors. Such differences, whether in small contiguous areas or over wider regions in the basin, may make it difficult for the surveyor to find places where he can obtain a fair sample of the amount of the snow cover. I suggest that in the cases where the forecasts have proved less satisfactory these possible sources of error have asserted themselves.

Captain Farrow contributes the following reply

The relative uniformity of water content in a given basin and often over a number of contiguous basins has been well established through sampling several thousand snow courses, some over periods exceeding twenty years.

The uniformity of course is not quantitative, but only relative as expressed in percentage of normal, nor is there any uniformity in depth. I think the relative uniformity first discovered by Dr. Church on Mount Rose remained obscured for so long because in the past only the depth of snow had been measured, either as it accumulated or in situ by means of snow stakes. As the density (*i.e.* the ratio between water content and depth) varies enormously, measurement of depth alone is practically valueless, and particularly so in the case of the snow stake. The same depth of snow at adjacent snow stakes read at the same time will often have quite different densities. Furthermore the same depth at the same stake will vary in density by as much as 50 per cent. from year to year.

The principal factors which effect the density of snow are six: Type of falling snow—specific gravity and size of flake (which are interdependent); rate of accumulation; total depth; rain falling on the snow pack; wind; sun.

In the Coast and Cascade Ranges the flakes are large and heavy and fall in a blinding smother which accumulates on the ground at an amazing rate. I have seen a twenty-hour storm yield a snowfall of over 48 inches. As this heavy snow increases in depth the average density increases on account of the weight upon the lower layers. Particularly at the lower altitudes the density is further increased by occasional rain falling on the snow-pack during periods of mild weather. Wind and sun are minor factors below timber-line; above timber-line however wind packing has a marked effect on density.

In the lee of the coastal mountains and in the Selkirks and Rockies the snow is quite different in type from that which falls on the seaward slope. The flakes are small and of low specific gravity. It accumulates much more slowly than the heavy coastal snow and drifts easily. In most years very little rain falls on the snow pack except in the spring. Where there is good timber cover sun and wind have only a minor effect on density, but as there are greater areas of open and semi-open country than in the coastal belt, wind is an important factor. Although the Selkirks and Rockies receive the same type of snow, have approximately the same amount of timber cover, are exposed to the same factors of sun and wind, the density of the snow is considerably higher in the Selkirks, where the accumulation on the ground is much deeper.

It is evident therefore that water content bears no relationship either to absolute or relative depth. But the various factors which effect density appear to produce approximately the same *relative* effect over quite large areas. Any attempt at forecasting run-off from depth of snow would of course be a failure.

A LABORATORY FOR PHYSICAL GEOGRAPHY

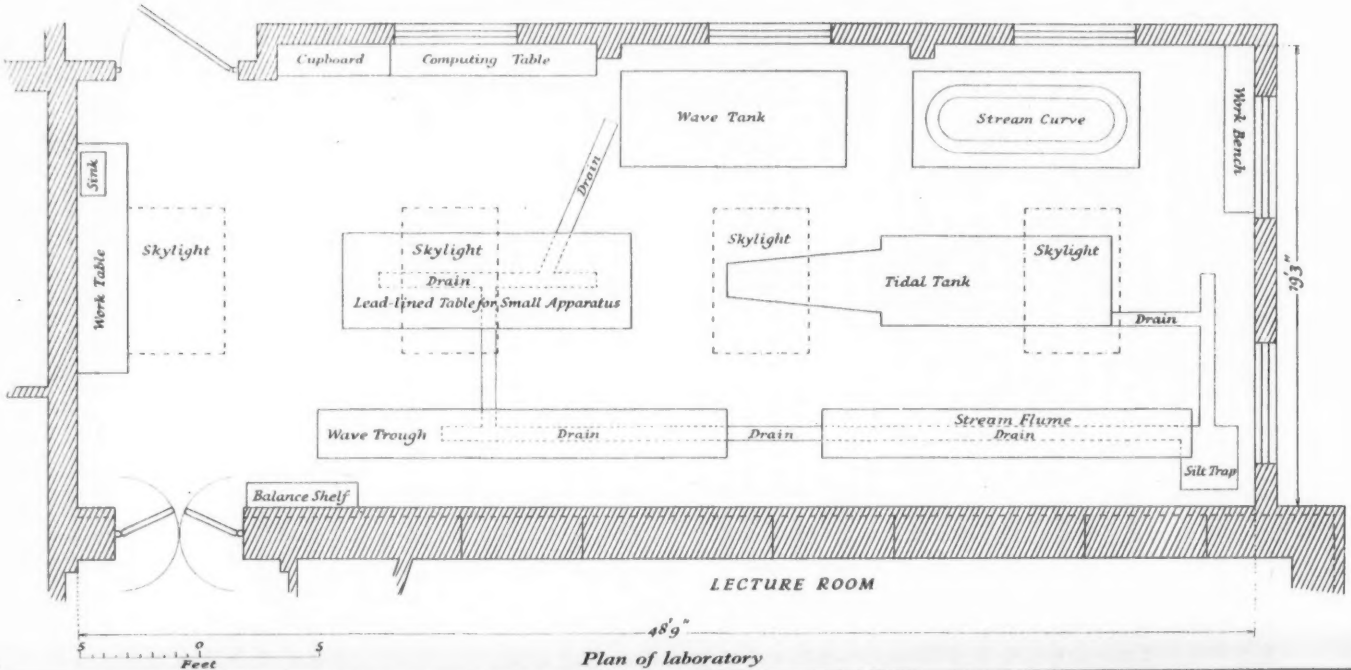
PROFESSOR FRANK DEBENHAM

FOR the purpose of this paper the title of Physical Geography may be taken to mean the study of those processes of earth, air, and water which affect the conditions under which we live. Many geographers would limit the study strictly to the effects only of those processes, the bare facts of man's environment, and leave the causes to specialist sciences. For those who believe in such rigid boundaries to the subject a laboratory for physical geography will have no appeal, but for those who feel that it is unnatural if not actually dangerous to divorce cause from effect, mechanism from final result, the idea of investigating the cause and nature of such processes must be welcome. We may therefore define the object of the physical geography laboratory as the study of field processes, usually in miniature, under conditions of close observation and control, with a view to ascertaining their mechanism, their stages, and their effects.

There is nothing very original in such a development, which means only that the geographer is following the example of most other field sciences, which have for long been accustomed to take certain of their field problems into the laboratory for elucidation and experiment. Nor is it anything new that problems of physical geography should be submitted to experiment since many of the inquiries of civil engineers are essentially special cases of physical geography. This Society in particular has encouraged such work for a long time past, two excellent examples being Dr. Owens' investigation of the movement of material by water begun in the year 1907 (*G.J.* 31 (1908) 415), and Major Bagnold's recent work on the movement of material by wind (*G.J.* 89 (1937) 409). That these papers have usually been presented by engineers and physicists rather than by geographers should be a spur to the idea that geographers should undertake similar investigations.

Some four years ago the Department of Geography at Cambridge decided to break ground in the direction of experiments in physical geography. We need not enumerate all the obstacles met with owing to scarcity of space and of funds, and not least to our own ignorance of how best to tackle the matter, for such obstacles are common to all new ventures. We should however like to record the assistance given by the University authorities and the satisfaction expressed by other scientific departments that physical geography was about to try and solve its own problems for itself.

At the British Association meeting in Cambridge in 1938 the plans for such a laboratory were announced, the room was completed and in operation in 1939, and in normal times there should now be a crop of results of considerable interest. Owing to the war the results have been but few and this paper must content itself with describing potentialities rather than actual achievements. A laboratory such as this is really a research unit, and requires researchers of ability and reasonable experience. Such cannot be produced at once, and there must first be a few years of teaching and sorting out of the research spirit amongst the taught. The apparatus is therefore used, at



Plan of laboratory

present, chiefly for teaching, and the work consists mainly of exercises with little more than that in view as far as the students are concerned.

The designer of the apparatus consulted the publications of previous workers in the same field, from Osborne Reynolds[1] to the continental investigators of the present day. He also received valuable advice from engineers and physicists. Those who know the work of these people and in particular that of Reynolds and Gibson[2] are well aware of the difficulties which face the designer when attempting to imitate nature on a smaller scale. The theoretical treatment of the problem by these and other investigators takes one a long way, but is apt to break down into mere empirical statements when the question of scaling down waterborne material is reached. For reasons which are not clear at present it seems that though the linear and time scales are related fairly rigidly, yet for silt the same effects as in nature are obtained if it is scaled down to only about two-thirds that of the material in nature. Fortunately there is a simple way of testing the validity of such empirical scaling down.

If for instance it is intended to investigate the tidal scour round such a place as Scolt Head Island on the Norfolk coast, a model is made to a given horizontal scale and a different vertical scale, relating the tide frequency and amplitude to those scales in accordance with theory. The model is made to surveys of, in this case, nearly forty years ago. Material of the assumed correct scale is then inserted and the model is run through forty years of tides in a few days. If the model island is then similar to the surveys of to-day the various factors have been correctly scaled, if not, a very likely source of error is in the material being used.

Fortunately the physical geographer is free, to some extent, from the limitations of the model engineer, since he is concerned with types rather than with actual places. He may for instance be investigating the effect of tidal currents round an island off a coast and will set up many shapes and sizes of island to find out the general principles. The engineer, on the other hand, concerned with, let us say, building a pier or dredging a channel in one particular case must observe all the details of scale and material as faithfully as possible. For that very reason however the physical geographer is a little apt to desert considerations of scale and reproduce features which are either wrong or are gross exaggerations of nature. Not unaware of these and other difficulties we set to work to design schemes, apparatus, and technique which would launch the work on a sound if limited scale, confining ourselves for the time being to the work of water on land-forms. The University permitted the use of a credit balance for construction and was generous with non-recurrent grants for apparatus. The building cost a little over £800 and all the equipment and apparatus about £300; so the venture is on a very small scale and the resources quite limited compared with those of ordinary scientific laboratories.

The building is 50 feet long by 19 broad and 9 feet high with a flat roof and top lighting. As the photographs show only too well, these dimensions cramp the five major pieces of apparatus. The water and power services

[1] Osborne Reynolds, 'Scientific papers,' vol. II.

[2] A. H. Gibson, Tidal model of the Severn estuary, 1933

Plan of laboratory

5 0 Feet

took up more room, and the designer had to show all the ingenuity he could summon in order to make the space serve his purpose. Wiring had to be provided for the A.C. of the main supply, and D.C. as well, for an electric master clock to work a chronograph in any part of the room, and for a 12-volt supply from batteries for the smaller motors. The ceiling therefore is a horrid network of piping and cables. Somehow, two workshop benches had to be fitted in, as well as an apparatus-cupboard and shelving. The criticism that it would be a nice laboratory if only there were no people in it was not without some force. However with forbearance on the part of the workers there is room for about a dozen people at a time, the size of our senior classes in the subject.

The lay-out of the room is shown in the diagram. To some extent the major pieces of apparatus come at present under two main categories, wave action (including tides) and stream action. For the first there are the wave trough for large-scale work; the wave tank, for medium-scale work; and the tidal tank, for small-scale work. For the second there are the stream flume, and the stream curve apparatus.

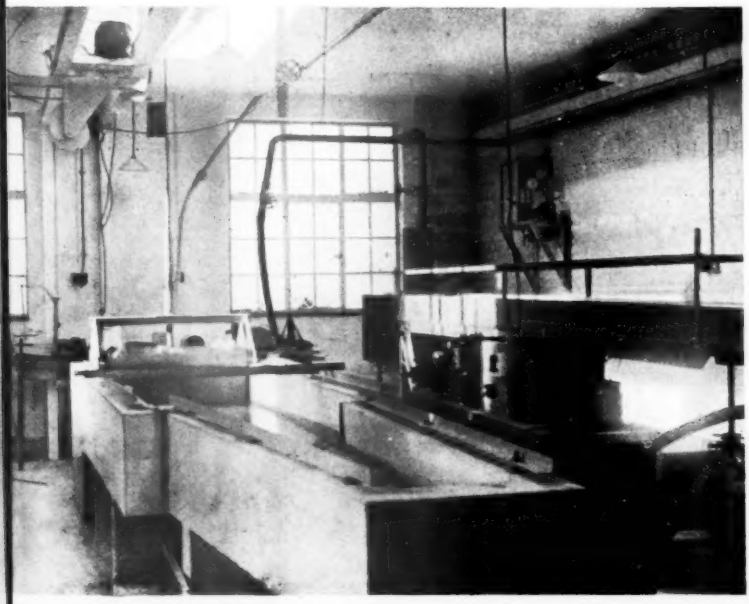
The wave trough is intended for studying the mechanics of wave action in shallow water and on beaches, and consists of a glass trough up which the wave travels, generated at one end by a paddle and breaking at the other end on an artificial shoreline. There are several ways of generating waves in such models, none of them entirely satisfactory, and three methods are used in the laboratory. It is quite difficult to produce true oscillatory waves such as are met with in the open ocean. Fortunately waves near coasts are composite, partly oscillatory and partly translatory, and these are not so hard to reproduce. In this apparatus a paddle occupying the whole area of cross-section is moved backwards and forwards, always parallel to the floor of the trough, and the gearing provides for producing a single stroke forward, a complete stroke forward and back or, as generally required, a continuous harmonic motion backwards and forwards. A rheostat varies the frequency of the waves, a Veeder counter records the number of waves in an experiment, and variable levers permit the length of stroke to be changed. The whole trough can be tilted lengthwise over about 10°, and the scale of the phenomena can be set at from 1/20 to 1/100 or less.

Naturally it was important to investigate first the nature of the wave produced by such a system, and it became clear after a rather complicated set of measurements that it was largely translatory, the particles of the wave moving in a flattened ellipse at the top of the water, to and fro on the bottom. It is therefore a close imitation of waves on a shallow coastline which have been checked by the shoaling bottom.

Having established the type of wave it was necessary to provide means to measure their characteristics, period, height, wave-length, etc. Of these the most difficult proved to be the wave length, or distance between successive crests, a detail of great importance. Various electrical and pressure methods have been tried, but so far we have not been more accurate in this measurement than about 2 per cent. Reducing the counter wave caused by the breaking on the steep-to shores is also difficult.

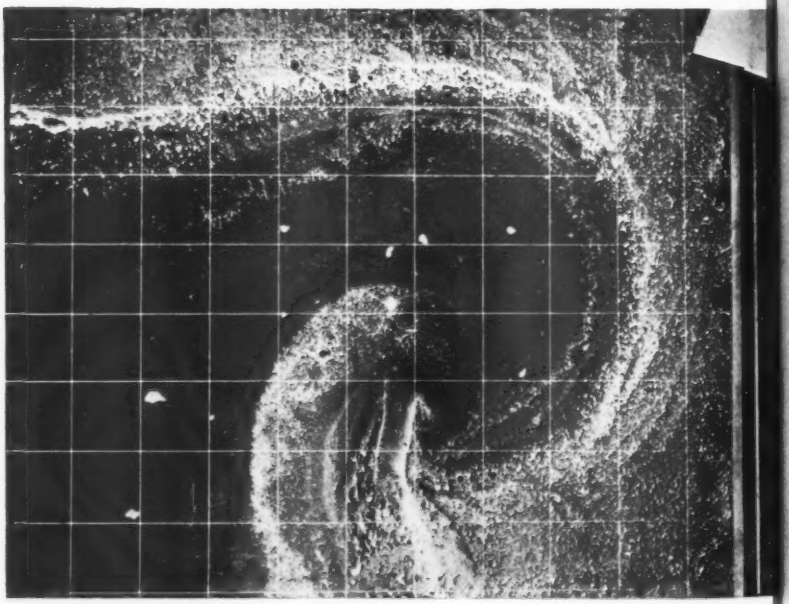
Subject to these failings however the apparatus appears to simulate wave

North side of laboratory: 1. Stream Curve; 2. Tidal Tank; 3. Stream Flume with Delta Tank beyond; 4. Wave Trough; 5. General purpose Lead-topped Table



Tidal Tank and Stream Flume. Driving gear for Tank is on girders by the skylight

South side of laboratory: 1. Stream Curve; 2. Tidal Tank; 3. Wave Tank



Hooked spit produced in Wave Tank, direction of waves from lower edge of pictu

action in nature sufficiently closely. Preliminary study has been made of several phenomena familiar on a beach but even yet imperfectly understood: of these mention will be made of two. When a wave breaks on the beach the momentum of water carries it up the beach. The elliptical motion in a translatory wave is such that just in front of the crest the particles are moving towards it, that is to say the direction of motion is against the wave direction in front of the crest, and with it behind the crest. We therefore have an indraught of water down the beach just before the break, due not to the slope of the beach but to the advancing wave itself. When the wave has broken the water sweeps up the beach and returns by gravity. The "indraught" of the approaching wave and the slope of the beach may or may not act together. If the wave length and period of the wave are suitable the broken water may sweep up the beach and return by gravity just in time to reinforce the indraught. With this condition we may speak of gravity and indraught as being in phase, and the general effect on the profile will be an even slope down from the upper reach of the wave, terminating in a surf bench just seaward of the surf itself. If however the action of gravity and of indraught are out of phase the sweep up the beach of the broken water will be interrupted by the back draught, and the curious phenomenon of the water splitting, some running on and some running back, takes place. The profiles of the beach are entirely different in the two cases, a more or less pronounced trench being produced in the second which is quite absent in the first.

The well-known phenomenon of a beach building-up in calmer weather and drawing down in rough weather is now under further investigation by the senior students. The relative mobility of sand and of shingle on a beach is of obvious interest either from the point of view of the coast erosion expert or from the holiday users of beaches. A series of preliminary experiments have been made on this subject with model beaches made up with varying amounts of shingle and sand.

Many minor phenomena of interest are illustrated by the wave trough, some of which must in due course be investigated. Amongst these are the formation and travel of wave-formed ripples over obstructions, and the mechanics of breaking surf. With the use of super-instantaneous photography and of the so-called "slow-motion" cine-film they may in due course be elucidated.

A method of applying a tide to this apparatus has been devised recently. Water is allowed to run in and run out of the trough alternately, by revolving a valve in a three-way stop-cock, the adjustment of the valve ports being such that the curve of rise and fall of the tide is nearly harmonic. The apparatus takes up but little room and should give a sufficiently wide range in time and in height of tide to extend the scope of the wave trough and wave tank considerably. No effects oblique to the shore line can be studied in this trough, since with the smallest effective waves the width of beach illustrated in nature is only about 20–40 feet. For what may be termed longshore phenomena therefore a different apparatus was designed.

The wave tank is a rectangular lead-lined tank, 8 by 4 by $1\frac{1}{2}$ feet, mounted so that it can be tilted to a moderate angle and with suitable arrange-

ments for supply, waste, etc. Its design is largely based on one used by Professor Ogilvie and his staff at Edinburgh many years before (*G.J.* 87 (1936) 145). In this tank the wave generator consists of a vertical metal plate extending across the whole tank, pivoted at or near the bottom and oscillated by a motor. It therefore moves the surface water through the length of its throw and the bottom water not at all, giving a less translatory wave than in the wave trough. By arranging that there shall normally be at least eight or ten wavelengths between the generator and the shore line being operated upon we are satisfied that the nature of the waves does not depart seriously from those found on such a coast as the East Anglian, though of course the artificial waves are much more regular and uniform.

The tank has been designed for work on a scale intermediate between that of the wave trough, whose normal scale is about 1/50, and the tidal tank whose scale is very much smaller. Sufficient action on shore lines can be obtained with waves of 2 cm. in amplitude, a scale of about 1/200. A shore line extending across the tank can therefore be taken to represent a length of 100 or 200 yards in nature if we consider horizontal and vertical scales to be the same. On such intermediate scales it was hoped to get sufficient dynamic similarity to study the longshore movement of material, and so far the tank's performance is promising.

Its first use was by a group of zoologists who borrowed it to investigate the distribution of shoals in bays in Lake Titicaca, Bolivia, which had a direct bearing on the distribution of plant and animal life in the lake. They expressed themselves as well satisfied with the results, as they were able to reproduce the features found in nature with sufficient accuracy for their purpose.

Closely related to the land-forms produced by the long-shore drift are the deflections of waves and the consequent currents, which form an integral part of the study. It is very easy to reproduce typical shore-line features with this wave tank, such as off-shore rolls, lagoons, shingle ridges, beach cusps, and even tombolas. The readiness with which such forms are imitated should however be a warning in itself that no real result has been achieved until the miniature land-forms have been related to the factors which have produced them, which means continual measurements of these factors and continual variations of the controlled conditions to sort out those which are fundamental from those which are merely contributory or accessory.

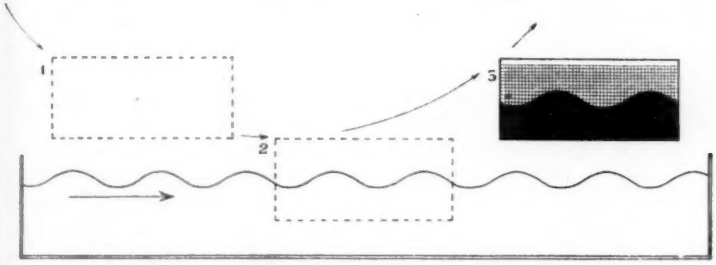
The ingenuity of our demonstrators is chiefly tested in the design of methods of measurement, as a few examples will show. One would think it easy to find the frequency, amplitude, and length of a series of neat little waves running tidily up a tank to break on a sandy shore. After trials of several methods, including electrical, the simplest way of all has proved the most efficient. A thin metal plate scored with a centimetre grid and painted matt red is held vertically over the tank in the direction of the run of the waves. After a few trial swings over the water to get the rate of passage of the waves it is dipped through the water at that rate and the wet silhouette on the plate can be measured immediately (see figure opposite).

The directions and velocities of the miniature currents set up in a bay subject to onshore waves is another problem. Surface currents are easy

enough, confetti being spread on the water and a longish exposure made on a photographic plate. The drifting white spots come out as elongated smudges which can be measured. Bottom currents are a little more difficult, while mid-depth currents, especially those with a vertical component, have so far quite defeated our efforts at accurate measurement.

The contour survey of underwater shore-line forms is yet another problem, not at all insoluble, but all the existing methods take up so much time that there is room for improvement.

At present the exercises mainly consist in establishing what are the equili-



Method of measuring wavelength and amplitude

brium profiles for various shapes of coast line. It is clear that a headland will gradually disappear and a bay will gradually fill up, but there are certain features in both processes which are obvious both in nature and in the model and which are related in some way to such things as direction, height, and length of waves. Until a large number of experiments have been done with these factors varied in turn no clear enunciation of erosion principles as shown by the model can be attempted. When it is, it will be necessary to go a step further and, modelling a real piece of shore line, see if there is really a close analogy in the two cases.

One of the chief advantages in the study of phenomena by models is the saving of time; the erosion of a year in nature can be imitated in the model in an hour or so without infringing the laws of kinetic similarity. When we can build a Dungeness in a fortnight and turn it out with a fair degree of accuracy we shall feel we have the responsible factors in our hands, if experiment alone will give the solution. The application of a tide to the wave tank will increase its application to nature enormously, though we have so far been fully occupied without that further complication.

The tidal tank is the most expensive and elaborate apparatus in the laboratory, and its purpose is perhaps the most ambitious. It is a rectangular tank of reinforced concrete, with 4-inch walls, 12 feet long by 4 feet wide, with a narrower extension of 6 feet at one end which can be shut off from the main tank. The tide is generated by a plunger at one end weighing about 300 lb. which is operated by a synchronous motor and balanced by a weight operating over a suitable cam to allow for the change of weight as the plunger sinks in the water.

The chief problem in the design was to prevent the motor and balance gear from taking up precious floor space, and this was finally effected by placing it in the ceiling supported on stout girders. It follows in its general plan the arrangements used in its much larger predecessors, the tidal tank used for the Severn Barrage investigation by Professor Gibson, and that in use by the Great Ouse Catchment Board at the present time. In these the mechanism was intended for a particular model whose scale was fixed and the range of tide known. The present tank is for more general cases of estuaries and inlets and the scale is therefore not fixed. This required variable gear to meet a reasonable range of scales, the only limiting factor being the duration of the tide, which is 58 seconds, determined by the constant rate motor used.

The operation of these variables may be illustrated by the first piece of work attempted. It was desired to investigate the effects of waves and tides round Scolt Head Island on the Norfolk coast, and the width of the tank permitted the horizontal scale of 1/10560 for the model of the island.

The relationship between tidal period and linear scales has been shown by Osborne Reynolds and others to be given by an equation which may be written $h/H=(lT/Lt)^2$ where t, l, h and T, L, H are the tidal periods and horizontal and vertical distances in the model and in nature respectively. Having made $t=58^s$ and $l/L=1/10{,}560$, and taking Tas$/2^h\ 20^m=44{,}400^s$, we have $h/H=1/190$, or say 1/200. There will therefore be reasonable kinetic similarity if the vertical scale is about 50 times the horizontal.

This theoretical treatment presupposes that the material used will permit such exaggeration, and it is over the material that the use of models begins to introduce difficulties. In the first place the rigid scaling down of the size of particles of material is impossible because fine mud would introduce colloidal effects which would be quite intractable. In the second place a large exaggeration of vertical scale imposes slopes of banks which are too steep for the material used and it must either be held together by mechanical means or the slope scale, if one may speak of such an incongruity, must be unreal. Compromises of an empirical nature must therefore be made, and this is where the experience of engineers with earlier tidal models is so valuable.

In the particular case cited the exercise broke down for a different reason altogether. Speaking generally tidal currents by themselves will not move material at all unless it is in temporary suspension. Floods in rivers and waves on the sea coast are the agents which produce this temporary suspension, so they too must be simulated in the model before similar effects can be produced. Not only would waves with an exaggeration of 1 to 50 between horizontal and vertical scales be impossible to produce, but their provision on such a small scale as 1/10,000 would be difficult and would allow the effects of surface tension to be unduly exaggerated. Accordingly, after some experiments with waves which were not in kinetic similitude with the other factors, the exercise was abandoned as being unreal with such a small tidal tank.

Two very troublesome hindrances in such a tank have now been successfully overcome: the growth of minute algae on the sand, which binds it, and the formation of a thin scum over the water surface, which damps all the effects and particularly those of waves. To meet these troubles an overflow arrangement was designed consisting of a bell-mouthed piece of piping

attached to a length of india rubber tubing which formed a coil in the bottom of the tank and then connected with the waste. The bell-mouthed end was coupled to the beam lifting the plunger in and out of the tank in such a way that it followed the tidal rise and fall very closely. At some suitable point in the tank fresh water was constantly running in and the bell-mouth kept an equal amount constantly running to waste. The continual change of water not only removed the scum from the surface but took away some of the factors leading to the growth of algae. An occasional dose of chloride of lime in the water disposed of the other factors favourable to algal slime.

For the production of waves in the tidal tank two or three designs have been tried, the most useful being the simplest. This, in outline, consists of a floating board to which the necessary pulsations are communicated via a cord, over pulleys which are linked to the beam which moves the plunger. This provides waves which do not alter greatly in height with the various stages of the tide. The pulsating board has guides to prevent it from drifting backwards and forwards with the tidal current. The tidal tank has not, as yet, been used to anything like its full capacity. The longer period of time required for experiments, the intricacies of its gearing and accessories, and the complications of tidal phenomena generally make it rather a forbidding piece of apparatus to senior students still at the learning stage. Nevertheless its performance so far promises well for the future research worker who can give it his undivided attention for any of the multitude of coastal problems which are related to tidal action.

The stream flume was designed for more comprehensive work than it has yet been able to tackle, though it is in constant use. Lack of space made it necessary to have only one such flume and to arrange that it might be used for more than one type of experiment; it has so far proved suitable for a variety of inquiries. Made of teak, it is tilted at one end by a powerful jack which can produce changes of slope over some 12°. At the other end is a reservoir which can be made to deliver a constant flow of water. This runs down the bed of the flume over any material which has been laid in it and flows out through a large funnel at the other end, carrying its load. It is then turned back the other way to run via a flexible tube into a large tank on wheels which can be made to simulate a pond or lake of comparatively still water, using baffles to reduce the kinetic energy as required. It is known as the delta tank, which sufficiently specifies its uses. From this it flows out via a suitably designed V notch to permit the rate of discharge to be measured quickly and, for strong flows, accurately. The delta tank also fulfils the purpose of retaining most of the solid material carried down, which may be wanted again and certainly is not desirable in the main sump. The flume itself is provided with various attachments for measuring slope, velocity, etc., but naturally the whole apparatus is not to be compared for accuracy with the giant flumes, glass-lined, which are to be found in hydrological institutes on the Continent, in America, and more recently in Ceylon. Partly for that reason, but also because of the inherent disadvantages of a flume which produces acceleration in flow, the results have to be handled with caution, and in general, they have to be treated as qualitative rather than quantitative.

The method adopted for adding material, sand, silt, etc., to the stream at its head is based on that used at the Imperial College of Engineering for somewhat similar work. The material in a perfectly dry state is brushed out of a small hopper by a low-power motor and running down a tube drops on to a cone suspended over the stream which can be set to direct it either evenly over the surface or more to one side than the other.

Such an apparatus provides the basis for a large number of investigations into the phenomena of stream erosion and deposition, and provided that the disadvantages referred to above are kept in mind, it will throw light upon a number of problems which are difficult to tackle adequately in the field. Some of the work already done will shortly appear as papers in this or other journals and needs only passing mention here. They will relate to stream development both in plan and in profile, and will naturally include a full description of the apparatus. Two of the difficulties, inherent in all reduced scale work, but particularly so in stream work, must be referred to. One is the problem of finding material, or a mixture of materials, which will approximate closely enough to the materials of nature not only as to scale but as to resistance or otherwise to erosion. This, in the end, must be a matter of trial and error, with every possible check to the appropriateness of the material finally used. It is not as insoluble a problem as the second one, which is that as the model is scaled down, the more dominating will such minor forces as surface tension and capillarity become. The mechanism of a tiny runnel must be different from that of a large river since the various factors are in a different proportion. One cannot in fact make a miniature Thames or even a small portion of it without doing such violence to vertical and horizontal scales that it can no longer be termed a Thames. Nor can one for a moment consider that a boulder in a mountain stream can be simulated by a sand grain in a tiny runnel which will be affected nearly as much by forces of surface tension as by the actual pressure of the water itself. Consequently we have already found ourselves wishing for a much longer stream channel, and regarding the conclusions so far reached as strictly provisional. On the other hand the construction of model streams on a reasonably large scale presents little difficulty other than its demand for space, and a natural development in due course will be an out-of-doors model stream, in fact a natural stream which is put under thorough control as to flow, measurement, and bed material. It is therefore a branch of the practical work which can be begun with the least demand upon instrumental equipment where there are natural streams in the vicinity.

The stream curve apparatus was originally designed for the investigation of the helical motion of a water particle in the bend of a stream, but has been in demand for other inquiries concerning river flow. As the photograph shows, it consists of an endless flume, the sides of which are of celluloid, shaped in plan like a racecourse. At the end of one of the straights a propeller of good design is driven from a variable electric motor by a flexible shaft. The turbulent motion is damped down by a series of screens and floats as it passes round the first curve, and by the time the current reaches the second curve it simulates very closely the characteristics of a normal stream. Such an endless

stream possesses several advantages over the more usual method of producing flow by a tilted flume. Not only are particles or material added to the water retained instead of being lost down a drain or sump, but there are no complicating accelerations. A single particle in suspension can be followed round and its motion observed over and over again, whilst the transparent walls permit full observation and the use of photography for recording paths in a vertical as well as in a horizontal sense.

A brief description of the experiment for which it was originally designed will show its possibilities. It was desired to measure and plot the movement in three dimensions of a particle of water passing round a curve. The stream was set running and when steady a drop of liquid of the same density as the water, but insoluble, was introduced from a pipette. The globule it formed, having a much higher index of refraction than the water, was easily seen. A graticule ruled on celluloid was bent round the curve and fastened and a similar graticule on a flat piece of celluloid was laid over the top of the channel round the curve. Two observers watched the globule closely, and at the ticks of a metronome marked its successive positions, one in plan, and the other in elevation. For low velocities this method was quite satisfactory; for higher ones a photographic method was devised but proved too expensive for the resources at command. The initial measurements were very suggestive and the inquiry itself is clearly an important one, but it proved too advanced to be handled by third-year students with only a few hours a week in the laboratory, and a Tripos examination ahead of them. The apparatus was therefore switched over to other and simpler exercises, concerned with the travel of ripples in bed material and their form round the curve.

There are always some minor problems being pursued with such apparatus as can be put together in the workshop. It was for instance found desirable to repeat some of the late Dr. Owens' original experiments on the rate of sand grains falling through water, using a slightly different method, due to the great advance in photographic technique since 1907. The use of high-speed and cine-photography is an essential part of the work in such a laboratory, but progress in this aspect can only be slow while it is mainly for teaching. The best illustration of its value comes from the wave trough. It is quite easy to produce a curling breaker and with a strong light behind it to photograph in slow motion the eddies and the motion of the particles of beach material. The best portion of the film can then be cut off and joined up as a loop of film. When run through the projector the process is shown over and over again until the eye can really take in fully what is happening. From this it is but a step to measuring the rates of motion from the film and elucidating much that, at full speed, would be quite beyond observation.

In conclusion, one or two of the side issues which invited some experiment may be mentioned. The siphoning action which in certain circumstances can take place in underground channels, especially in limestone districts, is well understood in theory. It is the probable cause of the intermittent flow of certain springs, and it is just possible that it may account for the Sabaoth river of Josephus which ceased to flow every seventh day. A model was made, first in plaster, which proved to be too porous, and then with glass tubing

and bulbs, which illustrated the various siphoning effects which could, theoretically, occur underground, and even give rise to a stream which would observe a day of rest.

A series of experiments which will interest those whose river banks are being rapidly undermined was that directed to finding the optimum angle of impact of a stream on a bank for producing maximum erosion. A wooden flume was made in such a way that the stream flow could be turned against a bank of glass at any angle. Observation of the eddies and of the path of material moved by them was easily made through the glass, and there were indications of some rather surprising results. Experiments on a larger scale might be of value to engineers, though it is probable that they have long ago investigated such problems in particular cases to their satisfaction.

A much more difficult inquiry has been begun into the causes of different types of landslides, a land-form which naturally grades into submarine slumping of recent sediments, but until we can afford more massive apparatus the results can be regarded only as suggestive.

This account of the new laboratory and the work so far attempted in it will be regarded either as an example or as a warning, and in either case it would be incomplete without drawing certain conclusions which we have reached as a result of the experience of three years of use. It is not enough to say that the senior students using it find it very interesting, and at times absorbing. That is only natural, as also is the fact that they acquire a new outlook towards the field work which is, or should be, in close association with the experiments. So far we have said little about its place in a university syllabus, its goal, and its scope, questions which will be immediately raised by those in the country who hold authority over geographical education. Obviously such an advanced treatment of physical geography is not for every geographer; it must be optional. Just as topographical surveying is not a part of the normal course but rather a special outcome of it, so the laboratory treatment of physical geography must be regarded as an extra in the curriculum, preparatory in fact to post-graduate research work. University geography is now, or should be, beyond the stage when its chief aim was the provision of teachers in the subject, and accordingly it must develop its various branches to the research stage. To do so on the human side does not present difficulties beyond those of providing the requisite staff, library, and map resources. For the physical side it is less easy, since there must be arrangements for field work, the provision of instrumental equipment and, what is more difficult still in an already crowded syllabus, instruction in laboratory practice.

Our experience so far has been that the chief hindrance to the experiments and exercises is that only a few of the students are accustomed to laboratory work, and are unduly dependent on the attendant for seeing that the apparatus is in order. A certain degree of handiness is of course essential for real research work, and the man who has to turn to a hard-pressed attendant whenever there is a small soldering job, or for wiring up a motor or changing the gearing, cannot expect to go very far in laboratory experiment. In the same way photography is a fundamental tool of the experimenter and he must understand its technique sufficiently to record his results himself. Accordingly

a modicum of instruction in such handiwork has to be given at present, though as the geographer who wishes to pursue the physical side becomes more common there will be less need for such elementary workshop teaching. These, after all, are but incidental difficulties; the fundamental requirement is adequate support from the educational world as a whole and university treasuries in particular. The latter will but slowly be converted to the view that Geography has a practical and somewhat expensive side, but a great deal can be done with small beginnings such as the laboratory described above. Once it has been established that laboratory research work in physical geography can be undertaken by a geographer, the university authorities will produce that support, and it is the hope of the staff here that in due course research papers based on the laboratory will supply that proof.

Since this article was written the exigencies of war have taken the laboratory from us, the apparatus has been dismantled, and the work completely suspended. The temporary check to what we now believe to be an important development in the advanced aspects of physical geography is unfortunate as, even in the reduced circumstances of the war, many useful lessons were being learnt about the technique. On the other hand it had gone far enough to convince those immediately concerned that the venture had proved its value and there is some prospect of strong support for the laboratory when it is returned to us.

NOTES ON AGRICULTURE IN THE LOW COUNTRIES

G. R. CRONE

THE physical environments within which the agricultural systems of Belgium and Holland have evolved have much in common. Developments in the two countries however present some differences, and the problems of recent years have been treated in dissimilar ways, yet the position in which they are now placed must be affecting their food supplies in a similar manner. In these notes an attempt is made to indicate the various factors, geographical, historical, and economic, which have produced these resemblances and contrasts.

The two countries occupy the western, maritime, end of the northern European plain, with its relatively cool summers, mild winters, and fairly evenly distributed rainfall. Apart from the Ardennes and the eastern borders, the period of frost is not prolonged, so that the duration of growth and the active farming season are lengthy. The main weather risk is a dull summer and a wet harvest, but lack of water is sometimes acute even on the Dutch polders. The present surface topography is largely the result of recent geological history. The basement rocks fall away in general from south-east to north-west, and this depression has been partially filled up by the material deposited in the deltas of the Rhine, Maas, and Schelde, which in the north has been modified by glacial action.

In general therefore the relief is low, and to that extent, favourable to agri-

culture, while the various deposits are arranged approximately in order of age from south-east to north-west. The upraised Ardennes peneplain in the south-east is succeeded by a belt of *limon*, probably wind-borne sands of

glacial origin resorted by water, which extends over the central high plains of Belgium, between the Meuse and the upper Schelde. This uniformly fine and permeable cover is very fertile, so that the areas in which it occurs in

Brabant, Hainaut, and Hesbaye form the most prosperous agricultural region of Belgium. Small areas are also found in Zuid Limburg, but this type is otherwise absent in the Netherlands. With the exception of Hainaut the proportion of pasture to farmland is lower than elsewhere in Belgium, and the farmers concentrate on the intensive cultivation of wheat, sugar beet, and oats, breeding horses, and fattening cattle, mainly from the Ardennes. South-west Hainaut and Southern Hesbaye produce three-quarters of the Belgian sugar beet. Beyond this *limon* in Belgium are the tertiary sands and clays of inland Flanders and the Campine. In the south-west, in Western Flanders, clays and clay loams predominate, with detached areas of sands, and the use of the land approximates to that of the central plains; in Eastern Flanders and the Campine sands and gravels are more conspicuous, and the country is by nature less fertile. Reference is made later to the intensive system evolved here. To the north-east these areas merge into the quaternary deposits of the great river deltas, which from an agricultural standpoint present similar characteristics. The sands and gravels being very pervious to water, the soils are strongly leached, and a pan tends to form in the subsoil. Thus before the agricultural expansion of the nineteenth century, the Campine, Noordbrabant, Gelderland, and Overijsel were largely covered by great expanses of *landes* and *bruyères*, with the original forest dwindling before the ravages of a peasantry practising an extensive form of husbandry. The extreme north-east of this belt was within the zone of ice action; in addition to moraines and other glacial features there are large areas of high moors, their waterlogged and acid soils even less productive in their natural state.

The continuity of this expanse of quaternary sands is broken by the belt of river clays deposited by the Maas, the Rhine, and the Ijsel, interspersed with patches of gravel. Most of this area must be protected from river floods by banks, and upon the ability to control the sub-soil water-level depends the distribution of arable and pasture: where the level is high, the land is in pasture. The gravel areas, better drained and giving a more easily worked soil, are the chief fruit-growing districts of the Netherlands, *e.g.* in Betuwe.

Fringing the coast, with the exception of the belts of littoral dunes, from West Flanders to northern Groningen is an expanse of sea clays and low peats, lying in general below sea-level. The older sea clays lying west of the Ijselmeer and north of Rotterdam were covered in part with peat beds during a period of lagoon formation, and in early centuries were liable to inroads of the sea. They were brought into use by "droogmakerij," that is, by protecting them by dykes, drying out the land by ditching and pumping, and by cutting away the layers of peat. On the older of these works, when technical methods were not as developed as they are now, the water-level cannot be kept sufficiently low for arable cultivation, and these polders were for long the centre of the Netherlands dairy industry, which had begun on the isolated patches free from inundation. Elsewhere the more recent polders, for example, Schieland, north of Rotterdam, and the Haarlemmermeer, are arable.

The feature of this dairying is that it is based on grass-fed cattle. These spend a great part of the year on the rich pastures, which incidentally require little or no fertilizers for their upkeep. During the winter period in the stalls

they are fed on meadow hay, with a small addition of imported cake, and calving is arranged to secure a constant output of milk. The dairy farmers do not rear stock: the animals are sold as soon as the yield begins to decline, and others are bought from the stockbreeders of the north-east. Apart from the supply of liquid milk to the cities, and the making of farm cheese (Gouda and Edam) the bulk of the milk goes to the cooperative industrial factories, the exports of butter and cheese from these forming an important item in the country's international trade.

The areas of recent marine clays, in maritime Flanders, Zeeland, Noordholland, northern Friesland, and Groningen, have been reclaimed directly from the sea. This work was easier and thus progressed more rapidly in the south, where the greater differences between high and low water made the evacuation of the surplus water through the sluices simpler than in the north. The soil, after it has been worked for a period to remove the excess of salt, is very fertile, and these regions are in the main arable, with large outputs of cereals and industrial crops.

In maritime Flanders however dairy farming and stock raising predominate, and in accord with the general tendency throughout the country, green fodder crops and pasture continue to encroach on the cereals. In the Netherlands' portion, arable farming, especially with the developments of recent years, has been maintained, though locally mixed farming and horticulture may predominate. Zeeland has always been the traditional wheat-growing province, and sugar beet and potatoes are also important. The recently reclaimed Wieringermeer and the northern margin of Groningen also grow wheat, and northern Friesland potatoes for food.

From this brief summary it is clear that much of the present area of Belgium and the Netherlands was not suited by nature for intensive farming, and that for agriculture to reach its present level much prolonged and well-directed labour has been expended upon the reclamation and improvement of the soil. This work in its two main forms, reclamation of the land from the water, and the bringing into cultivation of the waste, has been progressing for several centuries and is continuing. The work of recovery from the sea, generally well known, does not require detailed notice here. Dykes as protection against the sea were probably built as early as the eighth century; they were then continued along the rivers, and by the thirteenth century dams were being thrown across the mouths of the rivers to isolate their courses from the sea. Poldering, or the enclosure and reclamation of particular areas, began on a large scale early in the seventeenth century with the reclamation of the Beemster. It is noteworthy that much of this work was undertaken by merchants with the profits of overseas trade. Thus Dutch maritime expansion reacted on the development of agriculture, and further, through its commercial relationships, opened a market for the butter and cheese produced on these polders.

The extension of farming on to the sand districts, not perhaps so spectacular as the contest with the sea, has been no less important for both countries. It may be regarded as having begun in Eastern Flanders, although the progress achieved has long raised that region from the category of "waste"; it has for centuries been the scene of intensive cultivation, carried on in a great number

of small holdings which support one of the densest rural populations in western Europe. The original impulse in this direction is still debated. The most probable explanation seems to be that in medieval times the development of the cloth trade led to what were then dense industrial concentrations in Bruges, Ghent, and other cities. Owing to the limitations of transport, these could be supported only by the produce of their immediate neighbourhood, with which they were linked by water routes, and it was to meet this demand that the intensive Flemish system was evolved. This was based upon much manual labour, and the elimination of fallow. This was first secured by heavy dressings of manure, hence the great numbers of cattle kept, supplemented by all kinds of refuse carried out from the cities. Later the output was increased by the introduction of roots and the rotation of crops.

Whatever the original cause, this intensive cultivation continues, and the pressure of the rural population on the available land has resulted in a steady decrease in the average size of the holdings. This subdivision has indeed progressed to a point at which it threatens, if unchecked, the future of agriculture in this region through the dissolution of workable farms into numbers of uneconomic plots. In the rather similar conditions of the Campine and the sand districts of the Netherlands progress for long was much slower. The farmland consisted of small areas on naturally well-drained soils, worked in conjunction with pastures along the river courses. Large flocks of sheep were grazed on the surrounding heaths, and the fields were kept constantly under crops by the dung of these flocks and the stall animals, supplemented by the ashes obtained from burning of brushwood and turf. Increase in the farmland was therefore largely limited by the number of animals that could be supported. The decisive influence in expansion was the introduction about the middle of the nineteenth century of the use of artificial fertilizers, and improved methods of cropping. The most considerable progress was made on the sand districts of the Netherlands, reinforced by the later agrarian depression which sent thither large numbers of small farmers displaced from the grain-growing districts of the west. Mixed farming is general, providing pasture and fodder crops for the cattle. Throughout the sand regions much oats and rye are grown for this purpose, but, if the holdings are to be profitable, it is also necessary to raise catch crops of turnips, carrots, etc., after the main crops. With all this effort however imports of grain from overseas are also requisite, for example for the raising of pigs, originally begun with the bye-products of the dairies. The great rise in the Netherlands output of dairy produce is due very largely to expansion in these areas. In Friesland in particular, where stock raising is also carried on, areas of sea clays, peats, and sands alike all contribute to the one purpose, the upkeep of the cattle. With no large cities close at hand to absorb large quantities of liquid milk, industrial dairies have spread rapidly here, favoured by the cooperative instincts of the people, so that Friesland has now wrested the supremacy in dairy farming from the western provinces.

Development on the high moors of the north-east has followed a different line. In the seventeenth century settlements were established to bring the moors under cultivation. They were first drained by ditches and canals; the top layer of turf was removed and preserved; the turf was then dug away and

an arable bed formed by mixing the top layer with sand and sediments removed from the watercourses. The land was also maintained in fertility by keeping sheep on the unreclaimed moorland. The use of artificial fertilizers has now made this unnecessary, and animal husbandry plays no part in the system; the arable is used almost entirely to grow the special kind of potato used in the starch factories which have grown up here partly on account of the good sea communications, and also rye for the strawboard factories. Almost the entire output of these two products was exported to this country, and the economic depression of the thirties was felt severely in this region.

The developments sketched above have been carried out against a changing background of world economics. In the third quarter of the last century, western European agriculture on the whole was enjoying a period of prosperity, improved methods increasing production to meet the growing demand of the rising industrial centres for food supplies. But from about 1875 the effects of the extension of grain farming overseas and the rapid improvement of communications produced a great fall in grain prices, and arable farmers were obliged to seek alternative products, for both countries, Belgium as an industrial, and the Netherlands as a commercial power, adhered to free trade policies.

The chief effect in Belgium was a progressive laying down of arable to grassland, and a concentration on the home demand for meat and dairy products. In the Netherlands where the proportion of pasture was already high, no such spectacular change-over was possible. In dairying, efforts were directed to improving the quality of the pastures, to raising the standard of the produce, and to building up a large export trade. Simultaneously in the more purely arable districts attempts were made to find food and industrial crops of relatively high value and less exposed to fluctuations in price. Potatoes and sugar beet offered alternatives; in both countries the area under the latter varied according to the changes in the international sugar market, but eventually settled down to the area necessary to supply the home demand for sugar. Flax, hops, tobacco, and other crops have at various times also provided profitable alternatives, as has market gardening and fruit growing. Horticulture and glass-house cultivation, supporting a considerable export trade, has also developed rapidly around Ghent, Brussels, and particularly in Zuidholland on the southern end of the *geest*. Here, in the Westland, the climate is mild, the dunes form a shelter, and the mixture of peat and sand gives a fertile easily worked soil. Horticulture had long been a feature of the Netherlands, but it was only in comparatively recent years that it figured prominently in the exports, and spread throughout the country. This expansion was largely due to the improvement in the speed of communication with the great cities not only of the Netherlands, but also of western Europe, to which early varieties could be delivered by air. Another cause was the pressure on the land which tended to reduce the size of holdings and thus made it essential to raise produce with a relatively high value. Bulb growing also developed along the *geest* for similar reasons, and tends to spread on to the heavier clays of the arable regions. The total horticultural area in 1938 was about 56,000 ha., mainly vegetables and fruit, but bulbs (7800 ha.), nurseries (2600 ha.), and flowers (1500 ha.), were also important. During

this century the area has been expanding rapidly, by slightly more than a quarter between 1921 and 1930. The peak was reached by 1932, since when, owing to economic difficulties, it has been maintained at about the same figure. Glass-house cultivation has also concentrated in Zuidholland, and about four-fifths of the area in this province is in Westland and adjoining parts of Delftland and Schieland.

Present land use.—About 60 per cent. of the total area of Belgium is in farmland, 18 per cent. is forested, and about 7 per cent. is uncultivated waste land. In the Netherlands, the proportion farmed is higher, approximately 72 per cent., the woods are considerably less, under 8 per cent., and the uncultivated area rather more, 10·5 per cent., including water and swamp. This contrast is largely explained by the fact that the Netherlands include no region corresponding to the Ardennes; also part of the area in very small holdings are not included in these figures for Belgium.

The composition of the farmland also differs significantly. In Belgium three-fifths is arable, including rotation meadow, and two-fifths is permanent grassland. This proportion is approximately reversed for the Netherlands. As regards the arable, the proportion in cereals is slightly greater in the Netherlands and that in fodder crops approximately half the Belgian figure.

Before discussing developments of the crisis years, some further indication of the position of farming may be obtained from details of the numbers employed and the character of the holdings. The active agricultural population of Belgium in 1929 was 662,382, of whom approximately half were males. The great majority were farmers and members of their families assisting on the farms, hired workers representing only about one-tenth of the total. Approximately 17 per cent. of the total working population is engaged in agriculture, a proportion lower than any west European country with the exception of Britain. This does not take into account however the considerable amount of part time worked, which is perhaps equivalent to another 150,000 workers. The agricultural population is declining but it is difficult to estimate the extent accurately. The total for 1895 was returned at 1,204,087, but this included many children under fourteen, excluded from later censuses. Over the same period, 1895–1929, the number of male labourers had declined from 130,000 to 50,000.

As regards intensity of labour, for every 100 ha. of farmland, there were approximately thirty-six workers, the highest figures being found in East Flanders, the lowest in the Ardennes.

The Netherlands offer several contrasts to this state of affairs. First it is one of the few west European countries where the farming population has increased recently in numbers, though not relatively to the total increase in the active population. The number in 1929 was approximately 639,000, having risen from 570,000 in 1899. A further contrast is that five-sixths were men, and that the hired worker is relatively much more important. It is difficult to distinguish between a labourer who works a small plot in his spare time, and a smallholder who works occasionally for others, but it has been estimated that between 250,000 and 300,000 are primarily working for wages,

that is, about two-fifths, in contrast to one-tenth in Belgium. The density of workers on the land is also lower, approximately 28 per 100 ha. of farmland.

These divergent developments partly explain, and are partly explained by, the changes in the size and character of the holdings. In Belgium, neglecting for the moment the 840,000 holdings under 1 ha. in area, there were 292,263 farms over 1 ha. Of these no less than two-thirds were in the class of 1–5 ha., and little more than 4 per cent. exceeded 20 ha. This splitting up of the country into a great number of small holdings has continued for long. The tendency lately has been for the numbers in the classes above 10 ha. to decline or remain stationary, while those from 5–10 ha. have increased. This suggests that the minimum economic unit lies in the latter class. The tendency to diminishing average size is due partly to the laws of inheritance, which favour the division of estates, partly to the general desire to possess a plot of land however small, and in part to the well-developed and cheap communications, which enable workers to live at considerable distances from their factories and mines, and which provide special rates for those travelling to or from their holdings. These part-time farmers number several hundred thousand. This dual occupation affords a measure of security in times of industrial depression, but it may also tend to depress wage levels in the cities.

In the Netherlands, of the holdings over 1 ha. (234,145), 47 per cent. were in the 1–5 ha. class (Belgium, 66 per cent.), and 11 per cent. above 20 ha. (Belgium, 4 per cent.). Between 1910 and 1929, farms had increased in number by approximately one-eighth; the main increases being in the 5–10 ha. and 10–20 ha. classes, which both increased by one-third. Thus though the largest farms are disappearing, the tendency towards splitting up into very small ones is not so pronounced as in Belgium, mainly because the agricultural workers have not become intermingled in the same way with the industrial, and a large proportion are landless. The problem in the Netherlands, especially in times of falling prices, is to maintain the existing small farmers, particularly on the sand regions, where the farms tend to be uneconomic in size, and are often burdened with debt.

The measures taken to meet the economic depression are shown in the tables. They were not sufficient to check between 1929 and 1937 the turn over from arable to grassland in Belgium, though despite a decline in total area in cereals there was an absolute increase in the area under wheat. On the other hand, while the total farmland increased in the Netherlands, as the result of works such as the Zuider Zee reclamation, the arable area increased, and most strikingly, the area in cereals expanded. In particular, by restricting the sowing of sugar beet and potatoes, the area under wheat was nearly trebled.

Land use		*Farmland (incl. orchards)*	*Arable*	*Permanent grass*
Belgium	1929	1829	1236	526
	1937	1845	1051	714
Netherlands	1929	2264	933	1284
	1937	2332	986	1294

The figures for the Netherlands include horticulture.

Arable		*Cereals*	[*Wheat*]	*Food crops*	[*Potatoes*]	*Indust. crops*	[*Sugar beet*]	*Rotation meadow, fodder*
Belgium	1929	720	165	193	171	96	58	226
	1937	582	172	163	158	85	48	220
Netherlands	1929	439	45	261	144	127	55	106
	1937	552	129	229	112	98	42	106

Figures in thousands of hectares

In Belgium the measures taken to meet the crisis were less drastic. Primarily an industrial country, it was in her interests to promote the flow of international trade as much and as long as possible. In general an attempt was made to keep the price of food for the industrial workers as low as possible, and to give some security to the principal branch of farming, stock raising, and dairy farming. By the usual methods of import control and subsidy, the latter were protected against foreign imports of meat; steps were taken to keep the prices of fodder and grain for feeding stuff as low as possible, and the consumption of liquid milk was encouraged. In the interests of the arable farmers, the proportion of home-grown flour used in bread was raised, and assistance given to the growers of sugar beet. These measures were varied from time to time to meet changes in world prices, and on the whole, the farmers were left to adapt themselves as best they could to the changed conditions.

In the Netherlands the position was more acute, and state control consequently more comprehensive. The necessity for this was shown in the figures for the export of agricultural produce. The export of raw and semi-manufactured foodstuffs fell in value between 1929 and 1932 by approximately one-half, and manufactured products fell still more. Butter and cheese exports suffered heavily, but the crisis was perhaps felt most severely by the horticulturalists, who lost much of their foreign trade in fruit, vegetables, flowers, and bulbs. Other rural industries also suffered considerably: the starch factories, most of the output of which went to Britain, consumed 373,000 tons of potatoes in 1931–32, in contrast to over 1,000,000 tons in the previous season; the straw-board factories, using rye straw, were in a similar plight.

To meet this loss of income, the general plan was to raise home production of grains, both for food and fodder, to reduce the imports proportionately, and to maintain exports as far as possible by subsidies, standardization and grading of produce, and trading agreements. This policy undoubtedly raised prices for the home market—*e.g.* the butter subsidy was paid from a levy on liquid milk sales—but this was accepted as necessary to support agriculture, and this was counterbalanced on the farmers' side by a price for milk which returned a very low rate of profit. Where subsidies were paid for other products, it was of course also necessary to limit output, and this raised many difficulties, especially in horticulture, where the ingenuity of the gardeners enabled them to maintain output on a restricted area.

Ultimately therefore the state was controlling imports, subsidizing exports, determining the crops and areas to be sown, maintaining prices, in some

cases by destroying surpluses, and contributing directly to the expenses of the smallholders.

Under normal conditions, agriculture contributed an important share to the prosperity of both countries, besides giving direct employment to one-fifth of the workers. The Belgian farmers met all the home demand for milk and butter, and for much of the fresh vegetables and fruit. They also contributed to the balancing of the national income by exporting a considerable quantity of horticultural produce. Against this must be set off the imports of grain, tropical oils and nuts for cattle fodder, and artificial fertilizers.

The position was in general the same in the Netherlands, except that the exports were of much greater value. Upon these depended the employment of many workers in commerce, communications, and certain industries, so that indirectly the prosperity of agriculture affected the well-being of a larger proportion of the population than the fifth actually employed in it.

It will have been seen that the level of agricultural activity in both countries, but particularly in the Netherlands, depended upon a close adjustment to world demand, and that the less restricted the conditions of international exchange the higher the standard of prosperity.

The effect of enemy occupation on these countries is therefore clear. The most important are the further reduction, or perhaps complete cessation of grain imports from outside, both for bread and for animal fodder; the lack of supplementary rations of previously imported cattle cake for the herds, and the difficulty of maintaining fertility with reduced supplies of artificial fertilizers. On the other side is the disorganization of the export trade. The attempt to produce more grain and potatoes for home consumption can be made only at the expense of foods with a high health value, such as milk, butter, fresh vegetables, and fruits. In the case of the Netherlands, it is quite likely that a significant increase in the proportion of cereals in the rotation is scarcely possible without destroying the whole system. The plight of the agricultural countries of eastern Europe, where a low standard of living is associated with a close rural population, concentrating excessively upon grain growing for export, is frequently, and rightly, stressed. It is into a very similar position that the economic crisis and the war are forcing the farmers of Belgium and the Netherlands. Their standard of living in the past has depended upon accessibility to world markets, as buyers of grain, cattle fodder, and artificial fertilizers, and as sellers of agricultural products of high value, both in terms of money and of health. A satisfactory settlement of world agriculture must take into account the requirements of these small farmers of western Europe, as well as those of the "green belt" of eastern Europe and of the overseas producers of raw materials and foodstuffs.

SUGGESTED PRINCIPLES FOR THE USE AND SPELLING OF GEOGRAPHICAL NAMES—PART II

M. AUROUSSEAU, Secretary, P.C.G.N.

System of orthography

A SYSTEM of orthography consists of an appropriate script, and rules for its use. The recording of proper names from unwritten languages, and their transcriptions from foreign script, would be relatively simple if our use of the English alphabet were consistent. But the spelling of modern English is inconsistent, especially as regards the vowels. We use as many as fourteen ways of representing the sound of *e* in *be*. To achieve regularity in the spelling of foreign names we are therefore constrained to use our alphabet conventionally.

In the long debate over the most appropriate convention "it was the question of vowel-transliteration which gave rise to the first controversies, and we soon find transliterators inclined to separate themselves into two camps—the one asserting that there was some general way of pronouncing certain vowel-symbols, or combinations of symbols, in English, which, if adopted as the basis of transliteration, might ensure a correct pronunciation of Oriental words by non-Orientalists; the other despairing of extracting any order out of our chaotic vowel-combinations, and founding their system of transliteration on the more regular Italian or French method of vowel-pronunciation" (*sic*, Monier-Williams, 1891. He meant vowel-representation).

The need for systematic rendering of foreign names in the English alphabet was first felt in India, and in 1776 Halhed applied a supposedly English scheme of vowel-representation to the names transliterated in his 'Code of Gentoo Laws,' compiled by order of Warren Hastings. The principle was developed by Sir Charles Wilkins, and extensively applied by Dr. Gilchrist, who published the first volume of his English and Hindustani dictionary in 1787.

In 1788 Sir William Jones, first president of the Royal Asiatic Society of Bengal, applied a system to the transliteration of the Nagari alphabet, in which he renounced the English ways of representing vowels in favour of the so-called continental system, but retained the English values of letters representing consonants. He succeeded in adapting a conventional Roman alphabet to the transliteration of an alphabet richer, more logical, and more refined than the Roman: the Nagari alphabet as used in Sanskrit.

During the earlier part of the nineteenth century the Halhed-Gilchrist scheme of representing foreign sounds was widely used. Towards the middle of the century however fundamental research on the nature, recording, and transmission of sound, including that of human speech, was in progress. The work then being done by such men as Sir Charles Wheatstone and A. J. Ellis made possible our use of telegraphy, shorthand, and phonetic symbols. Ways more sensitive than those of Halhed and Gilchrist for the recording of language and for the transcription of foreign names became necessary.

In 1836 the Royal Geographical Society announced its effective adherence,

in the writing of geographical names, to the principles followed by Sir William Jones. In 1849 Sir John Herschel recommended Ellis' Ethnical Alphabet for use by the Admiralty, but in 1850 the Admiralty affirmed its faith both in Sir William Jones' principles and in the use of none but Roman letters by publishing and using a simple, conventional Roman alphabet devised by Captain (afterwards Admiral) John Washington.

In 1853 the Chevalier de Bunsen convened a series of alphabetical conferences in London, which led Max Müller, in 1854, to produce a Missionary Alphabet. He based it on the confirmation, by the physiologists of his time, of the analysis of the Nagari phonetic system by the ancient Sanskrit grammarians.

In 1855 Lepsius produced the first full account of his General Linguistic Alphabet. He accepted Bopp's use of the Greek symbol for rough breathing to mark the aspirated consonants. His work had far-reaching effects. His alphabet, for instance, was accepted at once by the Church Missionary Society; and it stimulated Max Müller to modify his Missionary Alphabet. This, in the modified form, was eventually accepted by the Clarendon Press for use in the translations of the 'Sacred Books of the East' (1879–1904). ". . . in these valuable books intended for the use of English-speaking Orientalists (including natives of India) throughout the civilized world, we have our common sounds of 'ch' and 'j' (equally common in Indian languages) represented by *k* and *g*. The consequence is that such names as Chandra-gupta, Sach-chid-ānanda, are spelt *K*andra-gupta, Sa*k*-*k*id-ānanda, while Jaina is *G*aina, and —the italics being often omitted by printers in quotations from these works— a false pronunciation of important proper names is being everywhere propagated" (Monier-Williams). This shows clearly the disadvantage of using devices which are readily neglected.

In 1859 Wade published his first statement on his system for the transcription of Chinese (Peiping dialect). It shows the influence of Lepsius in the treatment of aspirated consonants. And in 1859, too, a collection of 'Original papers illustrating the Application of the Roman Alphabet to the Languages of India' was published at the instigation of Sir Charles Trevelyan.

In 1863 Bell produced his Visible Speech Symbols, and so drew the line sharply between the literary conventions of written languages and the exact notation of spoken sound. His symbols were adopted by the Philological Society and the Clarendon Press for use in 'A New English Dictionary' (1884–1928), and have remained in use in supplements to, and abridgements of, the dictionary which have since been issued, though superseded in phonetics by the symbols of the International Phonetic Association (founded in 1886).

In 1867, Hepburn's system for the transcription of Japanese was published. In 1870 Sir William Wilson Hunter presented the first statement of his system for the writing of Indian proper names. A "generally scientific system," it adheres closely to Sir William Jones' scheme for Nagari, and was officially accepted in India in 1873.

By the third quarter of the nineteenth century systems for the recording and transmission of foreign languages, and for the transcription of foreign script, existed in confusing variety. In 1878 the Royal Geographical Society again stated its effective adhesion to Sir William Jones' main principles, and,

in collaboration with the Admiralty, and on the basis of Admiral Washington's conventional alphabet of 1850, developed a system of orthography which was not published until 1885. The R.G.S. System, as it was called, was adopted by the Admiralty, War Office, Foreign Office, and Colonial Office, and eventually also by the United States Geographic Board. The system permitted the doubling of a consonant to shorten the preceding vowel, a characteristically, though not exclusively, English device.

The Orientalists meanwhile, under the leadership of Monier-Williams, had been striving for international agreement on the transliteration of Oriental languages. The Tenth International Congress of Orientalists, held at Geneva in 1894, accepted a system proposed for the transliteration of the Sanskrit and Arabic alphabets, which was discussed at the Sixth International Geographical Congress, held at London in 1895, and accepted, with slight modification, by the Royal Asiatic Society of Great Britain and Ireland in 1896. Although this, like the Hunterian system, is in harmony with that of Sir William Jones, it leaves room for difference between the official and the scholarly treatment of Indian names. The Royal Asiatic Society's system was approved and recommended for use by the leading Missionary Societies of Great Britain and North America and by the Moravian Mission.

The P.C.G.N., formed at the instigation of the Admiralty in 1919, rejected the device used in the R.G.S. System for indicating the length of vowels. It produced the broader and simpler R.G.S.II. System, which was accepted by the Admiralty, War Office, and Colonial Office, by most of the British Dominions, and by the United States Geographic Board.

The R.G.S. System, being conventional, was no more phonetic than most other alphabetical systems. But it has been "taken (in flat contradiction of the declaration of its authors) to be a phonetic system" (Wharton). Its originators took "the true sound of the word as locally pronounced" for the basis of spelling, and aimed at "an approximation . . . to the sound. A system which would attempt to represent the more delicate inflexions of sound and accent would be so complicated as only to defeat itself" (Rules of the R.G.S. System as given in 1885).

The originators of the broader R.G.S.II. System announced their alphabet as phonetic (preface to 'Alphabets of Foreign Languages,' 1921, and specifically in that to the second edition, 1933). In their 'Rules for Spelling' they also repeated the statement that "every letter is pronounced," but eight consonantal sounds were represented in their alphabet by digraphs, of which the letters were not separately pronounced. And they said that "The system aims at giving a close approximation to the *local* pronunciation." This change, as compared with the earlier statement of the system, points to the need not of a simple but of a dual system, in which generalization will be possible in one direction (a broad system), and a more rigorous representation of sounds in the other (a narrow system).

Like the Royal Geographical Society under the R.G.S. System, the P.C.G.N. under the R.G.S.II. System now accepts the Hunterian spelling of Indian, the Hepburn spelling of Japanese, and the Wade spelling, as modified by Giles (1912), of Chinese names. The implications are important, and have not been fully appreciated.

Allowing that Wade and Giles were necessarily more concerned with syllabary than alphabet, and recognizing that Chinese languages are rich in vowel-sequences, comparison of the Wade-Giles, Hepburn, Hunterian, R.G.S., Royal Asiatic Society's, and R.G.S.II. systems shows that they all conform with Sir William Jones' main principles, except for the use of *j* in the transcription of Chinese. In fact a British conventional alphabet extending beyond the strictly official range of that of the R.G.S.II. System has come into existence during the last hundred and fifty years. It has minor inconsistencies, and exhibits conflicting ways of representing aspirated consonants. For the sound of *chh* in wit*ch h*azel Hunter provides *chh*, Wade *ch'*. And it is not alone in the field: the B.B.C. recently attempted to revive the use of the main principle of the Halhed-Gilchrist system in 'Broadcast English VI' (London, 1937).

In the following continuation of these suggestions the numbering of sections is continued from Part I (pp. 176–81 of this volume).

8. Geographical names, to be written satisfactorily for British use, require an ampler and more flexible alphabet than that of the R.G.S.II. System. The R.G.S.II. alphabet itself has passed the test of prolonged application and provides a satisfactory foundation. But we now need to assume a more critical attitude towards its phonetic reference, and towards the rules for its use, if we are to make it capable of natural extension. It is generally agreed that the following sounds should be represented, though not necessarily as here suggested. The statement amounts, in effect, to little more than a new presentation of what is already implicit in the R.G.S.II. System.

xx. Many other interests would welcome a generalized Roman alphabet applicable to the English recording or transcription of any language. To succeed, such an alphabet must be confined within narrow limits. English is written without diacritical marks, and our established habit is to let those prescribed, as for instance by the Hunterian system, fall into disuse. Scholars respect them, and a narrow system is necessary; but geographical names have continually to be printed, copied, telegraphed, and written on maps. Little besides the bare Roman letters will survive in popular use. It is vain therefore to propose a system in which italic or non-Roman letters are used together with the Roman, and which in its popular form makes use of diacritical marks and unfamiliar symbols. The claims of broad and narrow systems of orthography and transcription have been examined in 'Transcription of foreign names,' which appears in the Committee's glossaries of Modern Greek and Russian.

xxi. In an alphabet meant not for a particular language but for the representation of any language to a particular people, it is essential that no letter or device be used in an arbitrary manner. A sign, letter, or combination should stand for the same sound or modification of sound throughout.

xxii. In discussion of the alphabet suggested below, particular attention is drawn to the difficult questions of how to *indicate the processes* of nazalization, palatalization, and aspiration; and how to *represent the sounds* of the long neutral vowel, the glottal click, and *'ain*.

8a. The following *common vowels and diphthongs* are pronounced without rounding the lips.

xxiii. Sounds are grouped phonetically, but are given in English alphabetical order within each group, as will be seen by inspection of the right-hand column in the group.

Sound	*International Phonetic Symbol*	*Conventional Alphabet Narrow*	*Broad*
a in arm, Fr. pâle, Ger. Bahn ..	ɑː	ā	a
a in Fr. page, It. montana	aː	ā	a
a in Fr. patte	a	a	a
a in hat	æ	a	a
i in fine; ei in Ger. sein	ai	ai	ai
a in parent (nearly), Fr. maître, Ger. Fähre	ɛː	ä	ä
e in Ger. Bett	ɛ	e	e
This sound is rendered by both *ai* and *e* in the transliteration of modern Greek.			
ea in earth; i in bird; o in world; u in fur	əː	Wade's ê?	ö?
a in marine; e in Fr. le, Ger. bitte ..	ə	a, e, or u, according to local pronunciation	a?
This is the so-called neutral or indeterminate vowel. It is often misrepresented as ʌ.			
a in pay (nearly); e in Fr. thé, Ger. mehr	eː	ē	e
e in bet	e	e	e
ee in see; i in machine	iː	ī	i
i in Fr. si.	i	i	i
This sound is rendered by both *i* and *oi* in the transliteration of modern Greek.			
i in hit	ɪ	i	i
The long value of this vowel is still represented by *ee* in a few conventional names.			
â (formerly î) in Romanian; ı in Turkish; the letter *yehre* in Russian	ï	ī?	ī?
It is wrongly supposed by many to be guttural.			
o in son; u in sun and in Chinese tung	ʌ	ŭ	u

8b. The following *common vowels and diphthongs* are pronounced with more or less rounding of the lips.

ou in out; ow in cow; au in Ger. aus	au	au	au
This sound is still conventionally rendered by *ow* in a few Chinese names.			
aw in lawn; ou in pour; o in Fr. fort	ɔː	aw	aw
This sound is conventionally rendered by *o* in some languages (Tongan, Yoruba).			
o in not	ɔ	o	o
o in Fr. côte	oː	ō	o
o in November, Fr. eau	o	o	o
œ in Fr. œuvre	œː	ö	ö
œ in Fr. œuf; ö in Ger. zwölf ..	œ	ö	ö
eu in Fr. meule; ö in Ger. schön ..	øː	ö	ö
eu in Fr. feu	ø	ö	ö

Sound	*International Phonetic Symbol*	*Conventional Alphabet Narrow*	*Broad*
oo in food; u in It. cuna; ou in Fr. cour	u:	ū	u
ou in Fr. tout	u	u	u
oo in soot; u in put	ʊ	u	u
The long value of u is still rendered by *oo* in a few conventional names, and by *ou* in the transliteration of modern Greek.			
u in Fr. tu; ü in Ger. über	y	ü	ü
u in Ger. fünf	ʏ	ü	ü

8c. The *nazalization* of any vowel or diphthong is indicated in phonetic transcription by placing a tilde (˜) over the corresponding letter, *e.g.* sõ (Fr. son). There is no generally acceptable way of indicating nazalization in the conventional alphabet.

xxiv. The fundamental difficulty of representing foreign sounds in an English alphabet is clearly understood only by phoneticians. We have persisted in trying to express continental vowels in terms of English examples, and in believing that corresponding series of long and short vowels exist in English. But our common sounds popularly thought to be long vowels are mostly diphthongs, and our common short vowels are not the "continental" a, e, i, o, u. This is nowhere better illustrated than in the R.G.S. Rules themselves wherein examples of:

æ	e	ɪ	ɔ	ʌ
ɑ:	e:i	i:	o:u	u:

are given in the belief that they represent:

a	e	i	o	u
a:	e:	i:	o:	u:

Examples given by Wade, Hepburn, and Hunter are equally questionable. The differences are even greater in overseas English. The correct reading of a conventional alphabet is therefore unlikely until English-speaking people understand and draw the distinction between their own and continental vowels.

8d. *Semi-vowels.*

α. l in leave	l	l	l
Russian hard l; l in wall (nearly) ..	ɬ	l	l
β. gl in It. gli; ll in Sp. ello	ʎ	ly	ly
This is a palatal, not a palatalized consonant.			
γ. r flapped, rolled, or trilled	ɾ, r, R	r	r
δ. w in away; ou in Fr. oui	w	w	w
ϵ. y in yes; i in onion; the glide between many English consonants and long u, *e.g.* in few, beauty, tune, argue.	j	y	y
This sound is far less common in American English.			

8e. *Voiced consonants.*

ζ. English b	b	b	b
b in Sp. saber	β	b	b
η. d in English unstressed syllables; French d	d	d	d

Sound	International Phonetic Symbol	Conventional Alphabet Narrow	Conventional Alphabet Broad
θ. th in this; δ in mod. Gk.	ð	dh	dh
ι. g in go; gh in It. ghiaccia	g	g	g
κ. The soft guttural sounds of mod. Gk. γ before back vowels	ɣ	gh	gh
Parisian r *grasséyé*; Arabic *ghain*, غ	ʁ	gh	gh
λ. j in just; g in gem	dʒ	j	j
μ. v in van	v	v	v
ν. z in zone	z	z	z
ξ. s in pleasure; j in Fr. jour	ʒ	zh	zh
The Chinese variety of this sound is still conventionally represented by *j*.			
ο. Arabic *'ain*, ع	ʕ	[ʻ]	omit
8f. *Nasal consonants*.			
m in may	m	m	m
n in Sp. anfora	ɱ	m	m
English n	n	n	n
n in Sp. cañon; gn in Fr. montagne ..	ɲ	ny	ny
This is a palatal, not a palatalized consonant.			
ng in singer; Maori nga	ŋ	ng	ng
8g. *Unvoiced consonants* (lettered to correspond with their voiced counterparts given above).			
λ. ch in chop	tʃ	ch	ch
μ. f in for	f	f	f
The sound is still represented by *ph* in conventional (particularly ancient Greek) names.			
Japanese f	ɸ	f	f
ι. French k; English k without emphasis	k	k	k
The Semitic sound of Arabic *qaf* ق	q	q	k
ε. ch in Ger. ich	ç	kh	kh
κ. ch in loch; Ger. ach	x	kh	kh
ζ. p in English unstressed syllables; Fr. p	p	p	p
ν. s in sit	s	s	s
ξ. sh in show	ʃ	sh	sh
η. t in English unstressed syllables; French t	t	t	t
θ. th in thin; c in Sp. placer	θ	th	th

8h. The *clicks* used in some African and American languages can be recorded in International Phonetic script, but not in any acceptable way in the Roman alphabet.

Sound	International Phonetic Symbol	Conventional Alphabet Narrow	Broad
Glottal click (the first sound in a weak cough). Important in E. Polynesian languages	ʔ	[°] *e.g.* °a	omit

8i. *The Aspirate.*

h in her	h	h	h
h in hat, perhaps (emphatic)	ɦ	h	h

8j. *Aspiration* being normal to emphatic k, p, and t in English, the aspiration of consonants is imperfectly heard by unpractised English ears. Unaspirated foreign unvoiced consonants sound to us, at first, like their voiced counterparts. We hear the Chinese t'ang [Wade system] and tang respectively as tang and dang. Aspiration of consonants is important in Irish, and in African and Oriental languages.

It may be shown as follows	h	h	omit

8k. The *palatalization* of consonants (their pronunciation with part of the tongue touching the palate) gives them a so-called soft or liquid quality, in effect like the English glide between many consonants and *u*. It is important in Russian, in which a glide like the English glide also occurs but is not to be confused with true palatalization. Palatalized consonants are marked as follows .. .. ż, ḅ l' t'

8l. *Retroflex* (so-called cerebral or cacuminal) pronunciation, that is, the formation of sounds with the under side of the tongue pressed to the palate, is important in African and Indian languages. It may be indicated as follows:

[a symbol for each sound] [.]*e.g.* ṛ omit

xxv. The nazalization of vowels, the aspiration of vowels and consonants, and the palatalization of consonants are processes which operate in varying degree. They must be indicated where they affect meaning. It is necessary to distinguish between am and ham; pal (Hindustani) means moment, but phal means fruit.

9. Syllables which bear emphatic *stress* may be marked with an acute accent over the last vowel-letter.

10. *Tone* may be indicated by writing one of the marks recommended by the International Phonetic Association [ˍ, ˉ, ˊ, ˋ, ˆ, ˇ] not on, but before, the syllable affected.

11. *Rules for spelling in the conventional alphabet.*

11a. Local pronunciation is to be taken as the basis for spelling.

11b. Every sound is to be represented by its closest corresponding letter or letters, and with refinement enough to maintain essential distinctions, *e.g.* (Russian) ugol means an angle but ugol' means coal; and (Marquesan) °ua means two; ua, rain; u°a, lobster; °u°a, vomit.

11c. A letter or digraph is to be doubled only when a distinct repetition of the same sound is to be indicated, *e.g.* Nuusafee, *pr.* Nu-usafe-e; Jidda,

pr. Jid-da. It follows that such combinations as ou, sch, will stand for o-u, s-ch, *e.g.* Zlatoust, *pr.* Zlato-ust; Peschanka, *pr.* Pes-chanka; Trengganu, *pr.* Treng-ganu; and in the narrow system such combinations as bh, kh, ph (*i.e.* without ligature), represent the sounds in cab-horse, kick him, loop-hole.

IId. Hyphens shall be used only with particles, such as -i- in Fijian and transliterated Persian, *e.g.* Nuku-i-Ra.

12. The following tabulation of the conventional alphabet in its narrow form should be compared with other alphabets such as those considered by Monier-Williams.

Vowels: ā, a; ä; ē, e; ê; ī, i; ĭ; ō, o; ŏ; ū, u, ŭ; ü.

Semi-vowels: l, r, w, y.

Consonants. Unvoiced series in brackets:

	Nasal	*Plosive*		*Fricative*	
Laryngeal ..		(°) [glottal click]		(h)	h
Pharyngeal ..				(') [*'ain*]	
Uvular		(q)			
Velar	ng	(k)	g	(kh)	gh
Palatal				(sh)	zh
Dental	n	(t)	d	(s)	z
				(th)	dh
Labial	m	(p)	b	(f)	v

Compound: (ch) =(tsh); j=dzh.

xxvi. The limited use of q, the absence of x (which equals ks), and of c except in the compound ch, are particularly to be noted. [°] and ['] are letters; h, in Western European alphabets, is really used as a diacritical mark, like ['] and [.], which serve to indicate palatalized and retroflex pronunciation respectively. The established English use of h in digraphs which stand for fricative consonants (*i.e.* consonants which owe their quality to the frictional sound which accompanies their emission), is logical but unfortunate, for such consonants may also be aspirated. This makes ligatures necessary in the narrow system, if the digraphs are to be read unmistakably as letters, unless new letters are devised to represent most of our fricative consonants.

I hope that these suggestions will neither be accepted nor rejected summarily. The effort here has been to adapt existing means to general use. Little is changed, but much is regulated. Many interests will be served by a generalized Roman alphabet, but, unless it be tested before use, its application will lead to confusion. In my opinion five, or even ten, years' trial would not be excessive.

I thank those members of the staff of the Royal Geographical Society, and of the Committee's special staff, who have helped me to prepare this paper.

AUTHORITIES

Admiralty. 'A manual of scientific enquiry.' *Ed.* Sir J. F. W. Herschel. London, 1849, pp. 441–44.

'Eskimaux and English vocabulary.' [*Ed.* Captain J. Washington.] London, 1850, pp. ix–x.

Hydrographic Department. 'General instructions for the Hydrographic Surveyors of the Admiralty.' London, 1862, p. 25.

Admiralty. "Circular to Admiralty surveyors. Orthography on Admiralty charts." 10 August 1884.

—— "A system of orthography. Adopted by the Admiralty for sailing directions and charts." 6 pp. [London, after 1884 but before 1905.]

Naval Staff, Intelligence Division. 'Instructions for the spelling of place-names in foreign countries.' [London], 1917. Re-issued by the Clarendon Press, Oxford, 1918.

Anon. "Hints to navigators and discoverers on the nomenclature of hydrography and geography." *Oriental Herald*, 20 (1829) 114–23.

Australia. Inter-Provincial Geographical Conference, Melbourne, 1884. Reported by E. J. Forbes, R.G.S. Australasia (Victoria), untitled serial publication, 17, part 2 (1900) 10.

Bell, A. M. "English visible speech." *Brit. colon. Print.*, 1863.

British and Foreign Bible Society. "Literation and transliteration." Henry Morris. *Bible House Papers*, 5 (1901) 1–30.

British Broadcasting Corporation. 'Broadcast English VI,' by A. Lloyd James. London, 1937.

Burgess, Jas. "Geographical place-names in Europe and the East." Sixth Internat. G. Congress, London, 1895. Rept., 1896, pp. 493–503.

Burma. 'Tables for the transliteration of Burmese into English.' Rangoon, 1883, 2nd ed., 1896.

'Tables for the transliteration of Shan names into English.' 12 pp. Rangoon, 1892.

Canada: Geographic Board. Reports. Ottawa, 1899– (in progress).

Ellis, A. J. 'The alphabet of Nature.' London and Bath, 1845.

Eton, W. 'A survey of the Turkish Empire.' London, 1799, pp. xx–xxiv.

Gilchrist, J. B. 'A dictionary, English and Hindoostanee.' Calcutta, 1787–90.

Giles, H. A. 'A Chinese-English Dictionary.' London, 1892, pp. xxvii–xxviii; 2nd ed., 3 v. London, 1909–12. *Ref.* v. 1, pp. xvii–xviii.

Halhed, N. B. 'A code of Gentoo laws.' London, 1776.

Hepburn, J. C. 'A Japanese-English and English-Japanese dictionary.' Shanghai, 1867, p. vi; 4th ed. [modified orthography]. Tokyo, 1888, p. iii.

Hunter, Sir W. W. Letter to the Secretary of the Government of India, Home Department. *Gazette of India*, 31 May 1870.

'Guide to the orthography of Indian proper names, with a list showing the true spelling for all post towns and villages in India.' Calcutta, 1871. (Contains the fullest account of the system he proposed.)

See India.

India. 'Original papers illustrating the history of the application of the Roman alphabet to the languages of India.' *Ed.* M. Monier-Williams. London, 1859. (Prepared at the instigation of Sir Charles Trevelyan.)

Resolution of the Department of Revenue, Agriculture, and Commerce, dated the 20th August 1873, in 'A manual of surveying for India,' by H. L. Thuillier and R. Smyth, 3rd ed. Calcutta, 1875, pp. 408–11. (Official adoption of the Hunterian System.)

'The Imperial Gazetteer of India.' W. W. Hunter. 9 v. London, 1881, *Ref.* v. 1, p. xxxiv; 2nd ed., 14 v. Oxford, 1885–87. 3rd ed., 26 v. Oxford, 1907–09, v. 26 (atlas) revised 1931, *Ref.* v. 1, pp. ix–x.

Foreign Department. "Rules for the phonetic transcription into English of Tibetan words." W. F. O'Connor and C. A. Bell. *Foreign Dept. Proc.*, June, 1904.

—— and General Staff. 'A system for the transliteration of Persian, Afghan, and Arabian words.' Calcutta, 1909. 2nd ed., 1912. Reprinted 1916.

India, Survey of. "Rules for transliteration," in 'Hand-book of professional instructions for the Topographical Branch.' St. G. C. Gore and C. Strahan. 2nd ed., 1896, para. 78, pp. 42–44. (States that the system of transliteration adopted by the Government of India is "a modification of that proposed by Dr. Hunter.")

'Notes on the transliteration of place names from Persian or Arabic into Roman script.' R. A. Wauhope. Dehra Dun, 1918.

'Notes on the spelling of Turki, Tibetan, and Chinese place names. With glossaries.' R. A. Wauhope. Dehra Dun, 1919.

International Congress of Orientalists. Dixième congrès international des orientalistes, Genève, 1894. "Rapport de la commission de transcription." Suppt., 15 pp., to *Actes*. Leide, 1897, translation in *J. R. Asiat. Soc.*, 1895, pp. 879–92.

[International Geographical Congress.] Congrès des sciences géographiques, cosmographiques et commerciales, Anvers, 1871. *C. R.* 2 (1872) 160.

Siebenter internationaler Geographen-Kongress, Berlin, 1899. *Verhandlungen*, 1 (1901) 314.

International Geographical Union. Congrès international de géographie, Amsterdam, 1938. *C. R.* 1 (1939) 500.

International Map Committee. Resolutions and Proceedings of the International Map Committee assembled in London, November 1909. London, 1910. *Ref.* p. 4.

Deuxième conférence internationale, Paris, 1913. Paris, 1914. *Ref.* pp. 87–89.

International Phonetic Association, The principles of the. *Maître Phonètique*, September–October 1912, *suppt.*

Jones, Daniel. 'An outline of English phonetics.' 4th ed. Cambridge, 1934.

and Amerindo Camilli. 'Fondamenti di grafia fonetica.' 20 pp. London, 1933.

Jones, Sir William. "A dissertation on the orthography of Asiatick words in Roman letters." By the President. *Asiatick Researches* (*Tr. Asiatick Soc.*), 1 (1788) 1–56.

Lepsius, Carl Richard. 'Das allgemeine linguistische Alphabet.' Berlin, 1855.

Monier-Williams, M. "The duty of English-speaking Orientalists in regard to united action in adhering generally to Sir William Jones's Principles of Transliteration, etc." *J. R. Asiat. Soc.*, 1890, pp. 607–38.

See India.

Müller, F. Max. 'Proposals for a missionary alphabet.' London, 1854.

Newfoundland: Nomenclature Board [Decisions]. *The Newfoundland Gazette*, 1940– (in progress).

New Zealand: Honorary Geographic Board. *Bulletin* 1. Wellington, 1934.

Noel-Armfield, G. 'General phonetics.' 4th ed. Cambridge, 1931.

Oxford: University Press. 'Rules for compositors and readers.' 31st ed. London, 1938.

Clarendon Press. *See* Admiralty.

Royal Asiatic Society of Great Britain and Ireland: Transliteration Committee. "Report. (Adopted by Council, 8th May, 1894)." 13 pp. and two folded tables. Issued with *Journal* for 1894.

"Transliteration." 12 pp. Issued with *Journal* for 1896.

"Alphabet for languages not yet reduced to writing." Henry Morris. *Journal* for 1898, pp. 23–38.

"Transliteration of the Sanskrit, Arabic, and allied alphabets." Appendix to each number of *Journal*, 1900–21; reprinted in *Journal* for 1924, pp. 549–54, and at irregular intervals thereafter.

Royal Geographical Society. [Footnote on the orthography of geographical names.] *Journal*, 6 (1836) 51.

"System of orthography for native names of places" [The R.G.S. System]. *Proceedings, N.S.*, 7 (1885), pp. 535–536; revised. *Ib.*, 14 (1892), pp. 116–119; two new rules added, *Geogr J.* 2 (1893) 456–467; *suppt.* on Chinese and Russian added, 1894 (see *Circular Memorandum*, "The Society's Rules for the Orthography of native names," 11 May 1914); revised, 1899, *Yearbook and Record*, 1900, pp. 35–40; revised and reissued as a leaflet, 1905; reprinted, 1917.

"On the giving of names to newly-discovered places." *Yearbook and Record*, 1901, p. 42; and in 'Hints to travellers,' 8th ed., 1901, v. 2, p. 256a; repeated in 9th and 10th editions.

"The map on the scale of 1/1,000,000, compiled at the Royal Geographical Society under the direction of the General Staff, 1914–15." A. R. Hinks. *Geogr. J.* 46 (1915) 24–50.

"New geographical names," in 'Hints to travellers,' 11th ed., v. 2, pp. 209–214.

Union of South Africa: Departmental Committee on the form and spelling of geographical proper names. Report. Pretoria, 1939.

Union Postale Universelle. 'Dictionnaire des Bureaux de Poste.' 4th ed., 2 v. Berne, 1937.

United Kingdom: Ordnance Survey. 'Topography in the tropical forest belt.' *Training Ser.* No. 2, Southampton, 1931.

Permanent Committee on Geographical Names for British Official Use. "Rules for the spelling of geographical names for British official use. (Termed the R.G.S.II. System.)" *Geogr. J.* 57 (1921) 39–43, reissued as a leaflet, January 1921; 2nd ed., July 1921, reprinted in 'Alphabets of foreign languages.' Lord Edward Gleichen and John H. Reynolds. *R.G.S. Technical Series:* No. 2. (1921), xii–xv; 3rd ed., January 1924; 4th ed. (revised), 1932, reprinted in *Ib.*, 2nd ed., 1933, pp. xii–xv; amended *Ib.*, *suppt.*, 1938, p. 3; 5th ed. (corrected), *Geogr. J.* 97 (1941), 318–321.

—— [Lists of names in numerous countries.] 1921– (in progress).

—— "The spelling and pronunciation of geographical names for British official use." Lord Edward Gleichen. Internat. G. Congr., Cambridge, 1928. Rept., 1930, pp. 445–51.

—— "Transcription of foreign names." M. A., 'Glossaries: 1. Modern Greek.' London, 1942, pp. vii–xv.

United States: Geographic Board. Reports. Washington, D.C., 1892–1932.

Board on Geographical Names. *Decisions*. Washington, D.C., 1936– (in progress).

Hydrographic Office. 'No. 98. Report on uniform system of spelling foreign names.' Washington, D.C., 1891.

Wade, Sir T. F. [Syllabary drafted 1859. Statement by C. Gardiner in *China J.* 14 (1931) 7.]

and W. C. Hillier. 'Tzŭ Êrh Chi'. Shanghai, 1867, pp. 3–11; 2nd ed. Shanghai, 1886, pp. 3–17.

War Office. "Hints on reconnaissance mapping for explorers in unsurveyed countries." [1892], 7 pp.

Topographical Section, General Staff. 'Rules for the transliteration of place-names occurring on foreign maps.' A. Knox. London, 1906; reprinted 1919.

Wharton, Leonard C. "Transcription of foreign tongues." *Tr. Philolog. Soc.*, 1921–1924 (1928) 59–112. (Select bibliography in chronological order.)

SEVERE EROSION NEAR BLAYDON, COUNTY DURHAM

F. GRAVE MORRIS

ON Sunday, 22 June 1941, a thunderstorm in the Tyne valley with convectional rain of almost tropical character, caused damage of various kinds incidental to such storms. The most remarkable was the erosion of a considerable gully in the neighbourhood of Blaydon. Although severe and rapid erosion of this nature is well known in tropical and sub-tropical countries such as the Southern States of the U.S.A., it is happily of rare occurrence in our own land. It seems worth while to put on record the details of this unusual phenomenon.

This gully is almost a mile west of Blaydon Station, near the small hamlet

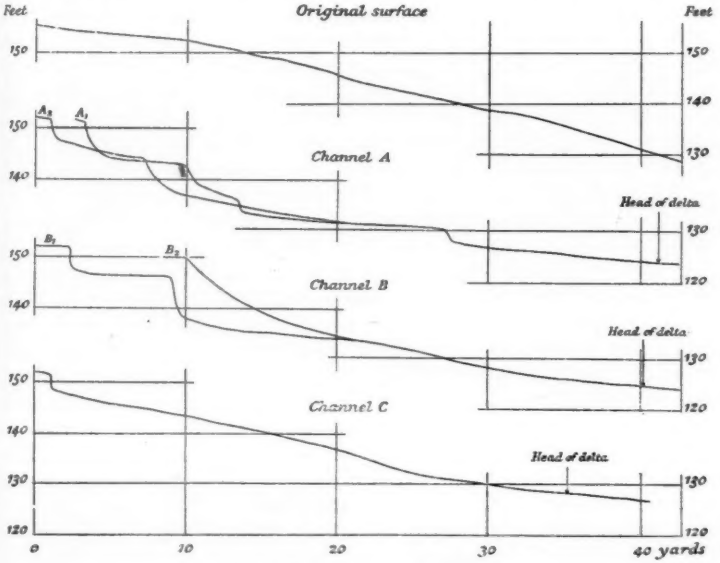


Fig. 1. Longitudinal profiles

of Path Head, which lies on the road leading southward from Blaydon to Ryton Woodside and Greenside. Just west of Path Head is a shallow valley down which a colliery wagonway now runs to the staithes at Stella, and the gully was cut on the northern slope of this valley.[1]

Three major factors appear to have contributed to the formation of this gully. First, the exceptionally heavy rainfall; secondly, the character of the material in which the gully was cut; and thirdly, the existence of ridges and furrows running down the slope. Although it is impossible to state with accuracy the exact amount of rain which fell during the storm, which lasted

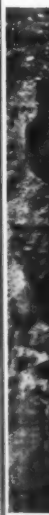
[1] O.S. 6-inch map, Durham, Sheet II, S.W., Northumberland XCIV, S.W.

about two hours, the nearest raingauge, that on the Forestry Commission's property at Chopwell, recorded 3·06 inches for the twenty-four hours ending on the following morning. At King's College, Newcastle upon Tyne, the amount recorded for the same period was 2·47 inches. There is little doubt however that almost all of this rain fell in a very short time.

The slope into which the gully was cut was the side of a drumlin the original profile of which is shown in Fig. 1. The top of the drumlin was almost flat, but its side formed a steep convex slope with a maximum gradient of about 1 in 4. The surface soil consisted of 6–8 inches of grey, stony material, rather light in texture, beneath which was a pebble band about 1 foot thick which in turn covered the soft, unconsolidated sand of the drumlin. Young turnips were planted in ridges which ran directly up and down the slope. The grey surface soil was easily removed by the powerful streams which gathered between these ridges, exposing the more resistant pebble band. Once the pebble band was breached it formed a local base level and affected headward erosion. Streams must have cascaded in small waterfalls over the edge, the back splash cutting out small caves in the soft sand beneath until the undercut pebble band collapsed. In this way the lip of the gully appears to have been retreating (Plates 2 and 3). It is however possible that water seeping through the furrows above the head of the gully saturated the more compact pebble layer and then, working through that, washed out the less consolidated sand beneath, thus forming the caves.

The streams rapidly enlarged their channels downwards and sideways, so that in a short time a number coalesced to form yet larger and more powerful streams which quickly destroyed the original surface over a considerable area. In the earlier stages, then, every furrow was an independent stream, but ultimately three major streams were formed, the channels of which were independent at their lower ends, leaving relatively undamaged tracts between. At the side of the gully there were furrows in almost every stage of destruction, thus providing a link between the undamaged furrows and the completely destroyed surface. By rapid headward erosion the larger streams cut back deeply into the slope, collecting as they did so many tributaries that a wide catchment was formed at the head of each. These later coalesced, thus destroying the whole of the original surface higher up the slope. The relatively narrow outlets and the wide heads of the channels can easily be seen on Fig. 2. The material thus removed was deposited at the bottom of the slope in three fan-shaped deltas which likewise coalesced to form one large one. When erosion ceased, the lip of A, the largest channel, was nearly 120 feet from the head of the delta, while the greatest depth below the original surface at any point in this channel was just over 10 feet. Channel B was almost as long and deep as A, but not as wide near the head. In fact it seems as though A were actively widening its head at the expense of B when the storm ceased.

The longitudinal profiles, drawn along the winding floors of the channels after all water had ceased to flow, are shown in Fig. 1. It is probable that as the volume of water slackened a certain amount of aggradation took place, and that when erosion was at its height the channels were slightly deeper. It was difficult to estimate the amount of aggradation, but it may have amounted to 2 or 3 inches near the outlets. Channel A, at the end of the storm, seems



3. C
case

1. General view of gully

2. Lip of the gully

3. Cave in lip of gully, spectacle case giving scale

4. Lower step in channel A

5. Upper step in channel A

6. Channel B

7. The Delta

to have had two heads, A_1 and A_2. The relation of the latter to channel B suggests that it was at one time the head of this channel but that A captured it. Through the accession of water that thus occurred A was deepened to a

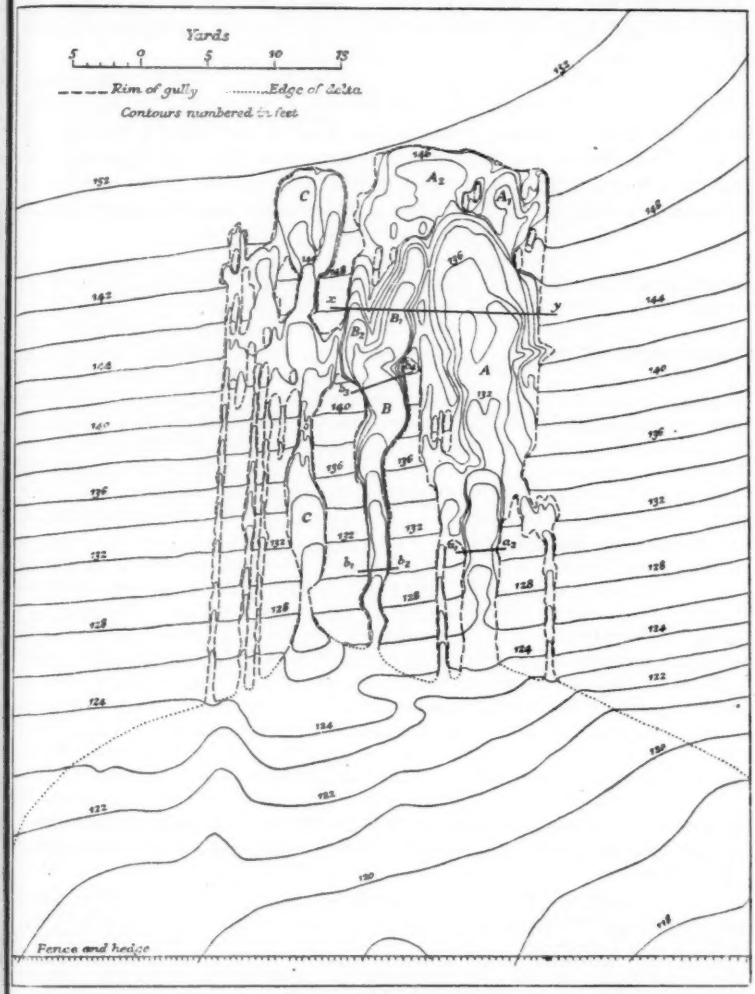


Fig. 2. Map of gully

somewhat greater extent than B. Channel A consisted of graded portions separated by marked steps. At approximately 43 feet from the head of the delta there was a step about 2 feet in height formed by a slightly harder band containing pebbles (Plate 4). From this point to the head of the delta the

floor dropped about 4 feet, a gradient of approximately 1 in 11. A much bigger step, about 7 feet in height, occurred 18–20 feet from the heads of both A_1 and A_2. This step was formed by a layer of cemented sand from 4 to 6 inches thick which protected the unconsolidated sands below (Plate 5). From the foot of this step to the top of the lower one just mentioned the floor of A_2 descended 8 feet in 56 feet, a gradient of 1 in 7.

Channel B showed an increase in gradient about 33 feet from its outlet, though it did not amount to a vertical step as in channel A. Below this point the floor descended 4 feet to the head of the delta, a gradient of 1 in 8. This channel also showed the big step, some 8 feet in height, near the head and between the foot of this step and the beginning of the increase of slope farther down the floor fell 5 feet in 45 feet, a gradient of 1 in 9. Channel

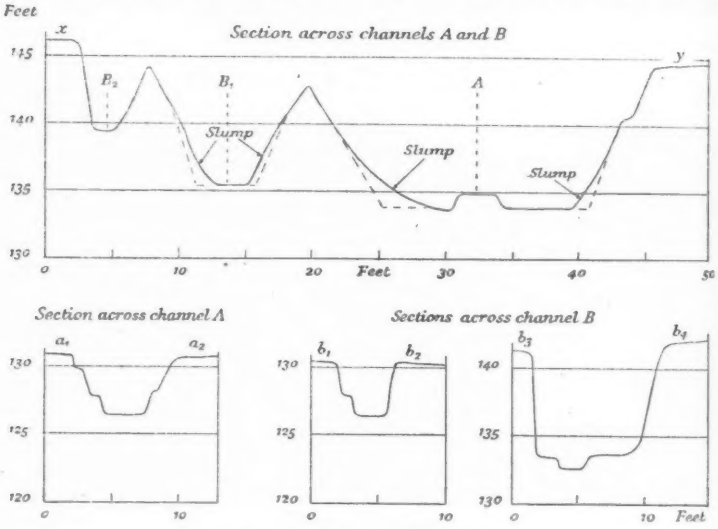


Fig. 3. Transverse profiles

C was not cut as deep as either A or B nor did it show such marked steps, although, as the profile shows, distinct changes of gradient occur at one or two points.

The transverse profiles of the channels are shown in Fig. 3. All of them were markedly U-shaped with steep or almost vertical walls and flat floors. A good deal of slumping took place naturally, and more was induced by the numerous visitors to the spot. However the cross section of the channels as they were actually cut was evident enough.

The material thus removed was deposited in a large and somewhat complex fan-delta, the extent of which is shown in Fig. 2 (Plate 7). The courses of the streams must have varied from time to time during the storm, but the resultant surface was a more or less smooth cone with its apex towards the gully. The front of the delta was held up by the fence and hedge at the

bottom of the slope, so that the gradient is not quite natural. In the absence of the hedge the delta would probably have extended somewhat farther. A small channel leading from the outlet of channel C across the mouth of B suggests that the former channel was the last to function.

The map illustrating this article is based on a plane-table survey. I am particularly indebted to my wife for her assistance in carrying out this survey. My thanks are also due to Dr. R. Raper, of King's College, Newcastle upon Tyne, for taking the photographs.

THE FIRST COPPER-PLATE MAPS

THE FIRST ENGRAVED ATLAS OF THE WORLD: the *Cosmographia* of Claudius Ptolemaeus, Bologna, 1477. By EDWARD LYNAM. *Jenkintown: The George H. Beans Library (Publication No.* 16), 1941. $17\frac{1}{2} \times 11\frac{1}{2}$ *inches;* [12]+34+[4] *pages. With* 4 *map-reproductions at end,* $10; *or with* 26 *reproductions in portfolio,* $33

THE production in war-time of a work like the present, involving intensive study of scarce and at the moment not easily accessible documents, is a *tour de force*, on the successful carrying out of which Mr. Lynam is to be congratulated. Special difficulties have been due to the printing of the work on the other side of the Atlantic, making proof-correction (some of it we believe done by cable) something of a nightmare. The reviewer suffers from some of the same disabilities, and an adequate notice is further impeded by war-time transport restrictions, making it impossible to send the complete work for the purpose, the copy received including four only of the twenty-six maps.

A few years ago Mr. Beans, known as an enthusiastic student and collector of old Italian maps, obtained in Italy a set of the maps, apparently in proof state, of the Bologna edition of Ptolemy's *Cosmographia*, the scarcest of all the printed editions, and as is now known the earliest to contain the maps. This supplied the idea of the present well-produced publication. For its purpose Mr. Lynam has made himself master of the most important literature on Ptolemy and his geographical work, including of course Father Fischer's *Magnum opus*; and although a good deal has been written on the edition in question, the literature is scattered and not all easily accessible, so that his scholarly study, in which our knowledge is brought to a focus, is very welcome. He begins with a conspectus of Ptolemy's work and the steps by which the *Cosmographia* was handed down in MS. until a new interest in it was roused at the Renaissance. Due emphasis is placed on the importance of the work as the first Atlas of the World, and as laying down for all time the essential principles of map-making. The estimate of one thousand four hundred years as the duration of the "uncontested sway" of the Atlas is perhaps a little excessive, when we think of the valuable work of the editors and map-makers of the early sixteenth century. Also one might hardly endorse the statement that Ptolemy actually "founded the belief in Terra Australis"; but these are minor matters. More important is the careful consideration of Ptolemy's technique, especially in regard to the projections to be used for map-making. An interesting point (new to the reviewer at least) is the suggestion that in drawing his own rectangular maps Ptolemy had some idea of the principle of latitude-spaces increasing towards the north. It need cause no surprise if one so competent in such matters should have had the

principle in mind, but failing more definite evidence the view can hardly be accepted without reserve. It was pointed out by Nordenskiöld ('Facsimile Atlas,' p. 22) that Pirckheimer, in his dedication of the Strasbourg Ptolemy of 1525, appears to recommend a rectangular projection with increasing latitude-spaces. The view put forward in Germany that the principle was known to the Nürnberg map-maker Etzlaub may also be noted.

Coming to his more special subject Mr. Lynam notes the importance of the German Donnus Nicolaus as popularizer of Ptolemy in Italy and Germany by his many fine MSS. of the *Cosmographia*, and the partial use made of them for the Bologna printed edition. The genesis of this edition was long obscure and its date conjectural (1472 and 1482 were both suggested) until proved to be 1477 by the researches of D. L. Sighinolfi. This student described in 1909 his discovery of documents recording the inception of the project of such a version in 1474 among a coterie of printers and draughtsmen at Bologna, and the partnership formed for its execution. The leading spirit was the noted miniaturist Taddeo Crivelli, who had worked for Duke Borso d'Este of Ferrara, and there become a friend of Donnus Niçolaus: like some of his predecessors, Mr. Lynam has little doubt that the preparation of the maps for the volume was mainly in his hands, and the decoration entirely so. Early in 1477 the partners contracted with the printer De Lapis to supply five hundred copies, and the first were delivered by June of that year. Meanwhile the text had been printed for the first time at Vicenza in 1475, and though this was full of careless errors, the Bologna coterie was content to follow it almost exactly. But the maps were a new departure as printed from copper-plates, and they forestalled by over a year those of the fine Rome edition of 1478 by Sweynheym and Bucking: they therefore have the distinction of being the first copper-plate maps ever issued. Mr. Lynam, quite naturally, dwells on their importance from this point of view, but one cannot help feeling that their claim to distinction is seriously reduced by their undoubted defects as compared with the Rome maps. Such defects are partially accounted for by the hurry with which the volume was rushed through the press. A large proportion of the maps were first offered in an unfinished state, lacking the waved decoration of the sea and other finishing touches. The final completion may be as late as 1479. Anyhow Crivelli can hardly rank alone as the "inventor" of this way of printing maps, for, as Mr. Lynam allows, the Bologna partners must have been well aware of the Rome project, which they only forestalled by unduly hurrying on with theirs.[1] The lettering is very inferior and many actual mistakes occur, as Mr. Lynam points out.

Another ground of distinction is the projection of the special maps, different from that used in any other version. Like that of the general map, it appears to be a conical one of some sort, but Mr. Lynam has failed, after many attempts, to trace the underlying principle. On some at least the latitude circles are not strictly concentric (as they are in the general map), but this may not be intentional. Judging from the two examples in the copy received, Italy and Africa,

[1] The preparation of the Rome maps, executed in a style that compels admiration, must surely have been in hand for some years, in fact the dedication of the work to the Pope in 1478 speaks of the three years devoted by Sweynheym to the training of the engravers before his death. This is variously given as 1476, 1477, or 1478. Whichever is right Sweynheym would almost certainly have planned the undertaking more than three years earlier and possibly begun work himself. It has been suggested that the lettering of the Rome maps may have been punched, and not engraved in the ordinary way; but this in no way lessens the merit of the result. Its excellence as compared with the style of the Bologna maps tells against Mr. Lynam's suggestion that some assistant of Sweynheym may have been bought over by Crivelli.

one might think them merely enlarged sections of the general map. This seems almost certain for the Africa, where there is no attempt at all to change the orientation, and this is not quite correct even for the Italy. May not the explanation be the difficulty of accurate enlargement from a small-scale model, and the evidence of carelessness in other respects?

Another interesting point touched upon is the decoration of the maps,[1] particularly the waved representation of the sea, the wind-heads, and the ornamental borders. The first may be thought, at least in Italy, somewhat too heavy to harmonize well with the more important parts of the map: the criticism hardly holds for the British Isles as reproduced by Nordenskiöld. The mode of showing mountains deserves some attention, and not being commonly used, may give help towards tracing the affinities of the Bologna maps, though Mr. Lynam does not enlarge upon this. It would no doubt have been outside the scope of the memoir to examine in detail the new matter added to the maps by the Bologna editors, and its derivation, but such a study would be well worth making. As Almagià points out in his Atlas of early Italian maps, the Bologna Italy offers a promising field for such research, and it may be suggested that a comparison with the much earlier effort of the maker of the map attached to the 'Chronicle of Jordanus' (of which there is a photograph in the Andrews collection at the Society) would be of special interest. Such studies will be helped materially by Mr. Beans' undertaking, when the complete issue becomes available. In the absence of this one cannot say much about the quality of the reproductions, which are photostats, not collotypes: at the prices charged one might have thought the latter not too great a luxury.

Mr. Lynam's study includes careful notes on the mistakes found in the Bologna maps, and the changes made in their later states, while Mr. Beans himself deserves thanks for painstaking inquiries respecting other known copies of the Atlas, and the state in which the several maps occur in each. The results are shown in a table giving details for twenty out of the twenty-four copies so far traced. Considering the difficulties involved by the war, misprints, recorded in a short list of *errata*, are remarkably few. E. HEAWOOD

[1] Mr. Lynam regards the decoration as a new departure. This may be true of the maps, but decorative borders had been used with effect for the accompanying texts in some at least of the MSS. of Donnus Nicolaus.

REVIEWS

EUROPE

THE TATRA MOUNTAINS. By V. A. FIRSOFF. *London: Lindsay Drummond*, 1942. 9×6 *inches; 128 pages; illustrations.* 10*s* 6*d*

This small book will appeal to all those who love mountains in general and the Carpathians in particular. It touches lightly though skilfully on many aspects of these mountains and the life of their inhabitants, such as folklore, peasant life, climbing, scenery, flora, and fauna. It ends with the coming of war to the region in 1939. The author has an enthusiastic style tempered with a dry humour, which shows to advantage in numerous passages, not least in his description of the many delicate situations which arose between the German and the other competing teams at the international skiing contest at Zakopane in 1939.

The author has more to say about the Polish side of the Tatra than about the

Slovak, but some of the customs he describes, particularly those connected with the high pastures, are common to many other regions of the Carpathians and even of the Balkans; for instance the word *baca*, meaning head-shepherd, is obviously the same as the Romanian *baciu*, while *vatra*, meaning fire or hearth, is common both to Romanian and Albanian.

The many beautiful photographs and the fine quality of the paper render the book particularly attractive in these days when both are apt to be meagre.

M. R. M.

ASIA

IN THE HIGH YEMEN. By HUGH SCOTT. *London: John Murray*, 1942. 9×6 *inches;* xx+260 *pages; illustrations and sketch-maps.* 18s

Al Yemen, the country "on the right hand" or, as some would derive it, the land of happiness and prosperity, has been for many years a source of interest not only to scientists but in a general way to many other people in Europe and America. It has been regarded as a closed country in recent years, but in earlier times travellers enjoyed greater freedom of movement either under the reigning Imam of the day or during the second period of Turkish dominion and there has resulted a considerable volume of literature which deals with the Yemen from many aspects. The present author and his companion, Mr. E. B. Britton, are entomologists of the staff of the British Museum (Natural History) at South Kensington who set out in 1937 primarily to penetrate the highlands of the Yemen, which are the most fertile part of the Roman *Arabia Felix*. In spite of numerous difficulties they succeeded in their purpose, and this account of their adventures has been prepared to provide a record of matters of general interest outside the purely technical nature of the expedition.

Force of circumstances made it necessary for the expedition to spend a portion of the time at its disposal in the Western Aden Protectorate, and though Mr. Harold Ingrams, of the Aden Protectorate Staff, has recently published an excellent book on conditions in the Aden Protectorates, Dr. Scott's colourful narrative of what he saw and learnt during the expedition's sojourn in the Amiri Highlands is both interesting and instructive, and it is a welcome addition to our meagre records of this corner of the Empire. As to the Yemen itself, the book contains a vivid account of the journey through the central Highlands by way of the picturesque towns of Ta'iz, Ibb, and Yarim to San'a, the capital. For all its medieval atmosphere San'a is not without modern equipment; bicycles and motor cars are in use, and wireless receiving sets, long forbidden by the present Imam, swiftly made their appearance once the royal permission was given. The expedition spent over two months at San'a, and some of that period was employed in visits to special points of interest in the country outside the city. When the time came finally to leave the Yemen, the party descended to the port of Hodeida, not, as was hoped for, by the old Manakha route, but by the motor road. This disappointment however was a minor matter in face of the considerable success achieved in other directions. Much of the charm of Dr. Scott's book is contributed by the beautiful photographs of which there are more than one hundred. They portray the little-known magnificence of the Yemen mountain scenery and the strange and fascinating architecture of a land which has preserved its ancient life intact against all but the most superficial intrusion of the modern world.

L. T. S.

Dr. Scott in his preface describes the scope of his book, and its arrangement in three parts. In the first he describes the purposes and methods of the British Museum (Natural History) Expedition to South-West Arabia, 1937–38. The second is his personal narrative of his journey in the Yemen and the Western

Aden Protectorate. In the third he is concerned with a summary of the history of the country, from the earliest times to to-day, and with the present state of the tribes.

This is a book for everyone, scientist, traveller, and armchair traveller alike. A number of other books have been written in recent years since Bertram Thomas' 'Arabia Felix,' and most of them have been good, but, in reading them, one is often inclined to turn back to the cover to assure oneself that the author is describing a country and a people familiar to one over a period of years. Dr. Scott's book is different. Here without doubt is the country and its people, vividly described and presented to the reader without any of the familiar romantic appeal which has marred so many accounts. We travel with him through the dusty heat of Lahej, across the bare foothill country and into the green shades of Wadi Hardaba. We climb the steep Khoreiba pass to the plateau of Dhala. He leads us to the edge of pacified country and from there we look across the vast and tumbled mass of the mountains of Yafa' and Halumein into country as yet unexplored. We journey with him to Ta'iz and San'a, that cool and sunny capital of the most ancient independent kingdom in Arabia. It is all here in photographs and text, the remnants of old civilization, the beautiful palaces, the grim forts, the lonely shrines, the high mysterious mountains, the Arabs and the Jews, and the Old Man of the Mountains himself, the sacred King of the Yemen. Of all that one might wish to know Dr. Scott gives us full measure, and it is all honest and painstaking showmanship, in an easy narrative style with flashes of humour and a sure power of description.

In case it should be thought that this book, excellent though it is, is just another book on South-West Arabia, it must be pointed out that it is more than a traveller's or an Official's tale. It marks the beginning of an epoch, that of the scientific exploration of the country. It may be said that this epoch began with Bertram Thomas' extensive explorations in the south-east of the peninsular and that while closing the epoch of travel in Arabia, by his crossing of the Empty Quarter, he also opened that of scientific exploration. Bertram Thomas penetrated unknown country and in it made his collections and his maps. Dr. Scott traversed country both explored and mapped, but in him we have the first expert to come to the country prepared to examine it for a specific scientific purpose, and to him and to his assistant must go the credit for the beginning of a new phase in Arabian exploration. But he has done far more, he has given us the first description in English of the ancient history of the country from pre-historic times until the present day. It is a fair summary of the little that is known of the subject but it calls for my only criticism, that history and legend should always be kept separate; Dr. Scott does not confuse them but folk tales should be kept separate from proved fact, the trappings of which they are so liable to assume. The book does not stop there, but ground-work is provided for geologists and anthropologists.

From every point of view this is a welcome book and not least from that of an official; for the scientific eye sees both wide and deep, and even to one who lived some years with the people and shared their lives Dr. Scott has many new things to say. It may shock one, but it is nevertheless true, that the plough photographed opposite page fifty, in use in pacified country within 90 miles of Aden, is the most primitive known form of ancient or modern plough. It was known in Egypt in 3000 B.C. The author describes methods of turning the soil, threshing and winnowing equally primitive and old. Such poor methods are the price Arabia pays for her exclusiveness. Civilization does not progress without the stimulus of contact, its natural trend is backwards. There is an uneven balance in a community which uses the most ancient of ploughs and the most modern of rifles.

R. A. B. H.

NORTH AMERICA

THE GEOGRAPHIC BASIS OF AMERICAN ECONOMIC LIFE. By H. H. McCarty. *New York: Harper and Bros.*, 1940. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* xxiv +702 *pages; illustrations and sketch-maps.* 18*s*

The publishers state that this book has been designed for use in introductory courses in departments of commerce, economics, and geography. In this country it may be regarded as a useful textbook for either Higher Certificate or first year University courses, or as interesting reading for those wishing to gain a wider knowledge of the resources and economic life of a great ally. This latter purpose is admirably fulfilled by omitting the first forty pages and the questions and problems at the end of each chapter.

The Foreword, Introduction, and the first two chapters: Geography and Economics, and the Geographic Environment, are devoted to explaining the scope of economic geography as interpreted in the subsequent chapters. The viewpoint adopted is not original and its exposition, subdivided into so many chapters and sub-headings, tends to be repetitive. Good points are the insistence on the great influence of a large variety of cultural factors, and also of a relatively small number of key industries, the locations of which go far to explain those of nearly all of the other types. Although the book as a whole bears witness to the influence in economic development of natural factors, such as soil, climate, and topography, their importance is unnecessarily minimized in the introduction. "In economic geography it is not necessary to make such a sharp distinction between the original natural environment and the man-made physical features with which man works. To the economic geographer it makes little difference whether a hydroelectric plant uses a natural waterfall or one created by a dam. . . . Economic geography makes little distinction between the human and the non-human features of the environment."

The greater part of the book consists of a regional study of the economic geography of the United States. The regions adopted are defined as the areas "in which a particular type of environment has encouraged the evolution of a distinctive type of economic life." There are ten of these major regions. Each of these has been described according to a standard pattern in which the location, surface features, and climate are first of all outlined. The types of development most closely associated with the natural resources, mining and quarrying, forests and fisheries, and agriculture, are next considered. These so-called basic economic interests are followed by descriptions of the cities and the manufactures and trade of the region, as well as by discussions on the more complex types of economic development. Obviously the emphasis must vary in the different regions. In the older and more highly industrialized areas stress is laid on such influences as historical factors, particularly those arising from an early start, and on inertia, mechanical technique, and the monopolistic nature of large financial and industrial concerns. In the farming regions of the mid-continent business is more highly competitive and there is a greater response to natural factors such as climate, topography, and soil. Finally, in the western half of the country natural limitations become even more compelling. It is just because the "relationship between natural environment and economic development are easier to comprehend than the historical and cultural relationships which prevail in the eastern areas" that the first region to be discussed is the Pacific Coast. In the succeeding regions, in the order of their treatment, the importance of physical influences diminishes and cultural factors become more emphasized. The most complex region of all, the American Manufacturing Belt, is thus naturally the last to be described.

The task which the author has set himself is immense. As he himself says, "the volume of information is so great that the problem of evaluation and elimination quickly becomes acute," and it is not eased by the attempt to compress so much into one medium-sized volume. Under these conditions it seems almost churlish to criticize statements of fact, or to draw attention to omissions. The chapter describing the economy of the Cotton Belt should be commended, for it admirably portrays in brief the life of this fascinating region. That the spirit of the south is in the author's blood becomes still more apparent in his somewhat one-sided consideration of the relative merits of the major textile-producing centres of the country. More could have been said with advantage about the problems of soil-erosion with respect to national economy, but regional references may be regarded as adequate. The individual descriptions of the principal cities and their occupations are a special feature, but in many instances their value would be enhanced if population figures were given, for at present there is no method whereby the relative importance of each city can be judged. In much the same way the importance of internal means of communication, and particularly of railways, has been stressed, but, in a country where private enterprise has been so dominant and where so many areas owe their life-blood to the efforts of one individual railway company, the mention of more of the lines by name would have been helpful. For example, can the real significance of Baltimore be understood without some reference to the Baltimore and Ohio Railroad, or of Philadelphia without some mention of the Pittsburg Turnpike?

The language of this book, in common with many recent American geographical publications, is often involved. A geographical jargon is being introduced which does not simplify the expression of geographical thought but makes straightforward statements incomprehensible to any one unused to the pseudo-technical terms employed. This difficulty is tacitly admitted by the author, for a Glossary of technical terms is included. The Glossary is however not particularly illuminating as its definitions are often as obscure as the terms themselves. Some of the non-geographical descriptions are moreover expressed in terms unfamiliar to many English readers.

The text is illustrated by a series of well-chosen, mainly aerial, photographs. The maps fit in well with the text, but much of the lettering has been so over-reduced as to be very difficult to read, and many of the descriptive legends are excessively long. At the end of each chapter a useful list of references for further reading is given, and there is also a series of questions and problems. Many of the latter cannot be dealt with satisfactorily without consulting the references, and their degree of difficulty varies greatly, *e.g.* "What is the geographic environment? Is there any essential difference between the geographic and physical environment?", and "Which city lies farthest west, Portland, San Francisco or Seattle?"

F. R. G.

ESQUIMALT NAVAL BASE: a history of its work and its defences. By F. V. Longstaff. *Victoria, B.C.* (*London: Hugh Rees, Ltd.*, 47, *Pall Mall.*) 1941. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* 190 *pages; illustrations.* $1.50

Esquimalt harbour is situated at the south end of Vancouver Island 3 miles west of Victoria, capital of British Columbia. Being some 60 miles up the Straits of San Juan de Fuca from Cape Flattery, it commands the parting of the ways for Puget Sound to the south-east, and the Gulf of Georgia to the north-west. Esquimalt (pronounced E *squī* malt) was an "official establishment" of the Royal Navy from 1865 to 1910, when it was taken over by the Royal Canadian Navy. The harbour was first entered by the Spaniards in 1790, and systematically charted in 1846 by the Royal Navy.

The author traces the naval history of this important base of the Pacific Station in painstaking detail from the early fur-trading and gold-fever days to the present. He deals with the gradual division of responsibility for the defence of the west coast of British North America between the British and the Canadian governments, with relevant Army as well as Navy aspects. A chapter is devoted to the significance of the opening of the Panama Canal on naval strategy of the Pacific coast. In a chapter entitled "Commanders-in-chief of Ships on the Pacific Station" we find the origin of many names better known to the layman for their geographical significance, such as Seymour, Hornby, Moresby, Powell, Denman, and Hastings. A useful chapter is a chronological array of important maritime events on the West Coast of America from 1513 to 1913. There are several biographical sketches, including one of the late Lieut.-General Sir Percy Lake, as appendices. The plates are a fine collection of historical photographs of H.M. warships and their crews which used the Esquimalt Establishment during the nineteenth century.

Major Longstaff has produced a compendium of undoubted value to the serious student of West Coast naval history, and has refrained from romancing to amuse the casual reader. G. S. A.

CENTRAL AND SOUTH AMERICA

THE FACE OF SOUTH AMERICA: an aerial traverse. By JOHN LYON RICH. (Amer. Geogr. Soc. Publn. No. 26. Ed. by JOHN C. WEAVER.) *New York: Amer. Geogr. Soc.*, 1942. $10 \times 7\frac{1}{2}$ *inches;* xviii + 300 *pages; illustrations and maps*

As the author states in his introduction, this is essentially a book of pictures—not random snapshots but a carefully selected series of photographs taken from the air during a tour of South America by the regular planes of Pan-American Airways. Dr. Rich, a professor of geology at Columbia University, has been able to pick out innumerable features which would pass unnoticed by the ordinary descriptive writer. The text brings out clearly and fully the salient points in each photograph, and each dovetails into the next with attractive smoothness, so that the reader is able to follow the course of the flight and observe the broader characteristics of the landscape.

The route followed the east coast from Trinidad to Buenos Aires via Georgetown, Belém, Recife, Rio de Janeiro, São Paulo, and Ascención, thence west across the Argentine pampas and the Andes via Cordoba and Mendoza to Santiago, and back along the west coast to Panama, with a side-trip to Bogotá. All photographs were taken with a miniature camera using 35-mm. motion-picture film. With the aid of the American Geographical Society's 1/M sheets of Hispanic America, and by notation of the time at which each picture was taken, the camera stations were fixed approximately along the flight line. In many instances three-point resections were made from recognizable landmarks. The photographs are exceptionally clear and brilliant, particularly in view of the fact that they were taken through the glass windows of the plane. An excellent series of flight-maps is included, on which the position of each camera station is marked, with the area comprised in each photograph.

Copious notes were made *en route* and the physiographic, geological, and vegetational features of the landscape flown over are described in detail: in the Guianas the coastal fringe of plantations with the hinterland of unbroken forest, the interesting deflection of the rivers caused by the north-westward coastal drift, and the drowned mouths of the Essequibo and other rivers. Views taken farther south show the drought region of north-east Brazil, the intensely

cultivated regions near Rio de Janeiro, the partly submerged coastal range which terminates in Cabo Joatinga, and the monadnocks, residual granitic cores rising above the general level of the topography. There are some fine photographs of the Iguassú Falls and of typical culture and soil patterns of the plains of Paraguay and Argentina with explanatory notes. The flight over the Andes from Mendoza to Santiago provided some interesting examples of the interpretation of geological structure from air photographs. The intense mineralization of the desert regions of northern Chile and Peru is also clearly shown. This book demonstrates an original use of air photographs, as distinct from aerial survey, to give a general pictorial panorama of a landscape.

J. H. T.

ITINERARIO DE UN GRAN VIAJE POR LA VIDA. By CARLOS LERMITTE. (In Spanish.) *Montevideo: Monteverde*, 1941. 10×7 *inches;* 222 *pages; frontispiece*

Dr. Carlos Lermitte's book is a detailed appreciation of the life, scientific work, and publications of a distinguished Uruguayan geographer, the late Professor Elzear Santiago Giuffra.

Dr. Lermitte, himself an authority on geographical instruction in Uruguay, pays sympathetic tribute to his colleague, whose career was all too short. Born in Montevideo in 1891, Giuffra died in his native city at the age of forty-eight, but, an untiring writer, he published no less than thirty-eight works (the first when he was sixteen) dealing with geographical, meteorological, and climatological subjects. His 'Geography of Uruguay' is perhaps most used in schools, and his study 'The Republic of Uruguay' (1935) is considered the most important. Giuffra was Professor of Geography in the University of Montevideo, and, for a time, Director of the Astronomical Observatory; he was responsible for the eventual foundation of sections devoted to geographical study in the higher educational centres of Uruguay. Much of Giuffra's work was devoted to the elucidation of Uruguay's physical situation. The question of legal jurisdiction over the Rio de la Plata was one problem in which his work was recognized as of national importance; while his reputation abroad was made apparent by the recognition accorded to him during European journeys in 1931–32. His last publication, 'El Uruguay en el Mundo,' appeared in the year of his death, 1939.

L. E. J.

PHYSICAL AND BIOLOGICAL GEOGRAPHY

SEDIMENTARY PETROGRAPHY. By H. B. MILNER. Third Edition. *London: Thomas Murby*, 1940. $8\frac{1}{2}\times5\frac{1}{2}$ *inches;* xxiv+666 *pages; illustrations and diagrams.* 45*s*

Sedimentary petrography is a tool used by certain specialists in their analyses of rocks formed by wind or water, for purposes scientific, economic, or philosophical. It started as an art which developed little by little and was principally concerned with rock particles separated from one another by differences shown in their individual specific gravities. It assumed some importance during the war of 1914–18 as a help to finding minerals, supplies of which had been cut off or curtailed, from the deposits nearer home. During that time and since then more and more physical properties of matter have been made use of and apparatus has been devised to detect or to concentrate grains from a silt or sand or to find some desirable or harmful constituent of a cement, coal, or clay.

The author, after a sheaf of prefaces and an introduction, devotes some two hundred pages to theory and technique of various methods of approach to the problem of intimate study of a sediment in whole or in part. The devices employable are gravity, flotation or surface tension, electric, and magnetic separations

and the use of X-rays, spectra, and fluorescence in special cases. There is a dissertation on microscopic studies and upon certain microchemical experiments. Then comes a catalogue, one hundred and thirty pages long, in which the minerals concerned are arranged alphabetically and their properties recorded. The results obtained are discussed in relation to their application in several trades of which the detecting of chosen horizons in oil wells is one of the best known and the helping to convict criminals the least. This section, with appendices and indices, takes up the final three hundred pages.

It is not easy to see how the subject is likely to benefit the geographer, although the stratigrapher, in his role as a palaeogeographer is aided by knowing the possible source of fragments found in rocks. From this he can perhaps realize old landscapes more certainly. The research worker however, addicted to these pursuits, will be truly thankful for this compendious work. J. V. H.

LANDSCAPE AS DEVELOPED BY THE PROCESSES OF NORMAL erosion. By C. A. COTTON. *Cambridge: University Press*, 1941. $8\frac{3}{4} \times 5\frac{3}{4}$ *inches;* xviii + 302 *pages; illustrations and diagrams.* 21*s*

Students have been fortunate during the last few decades in having some subjects ably brought together for them between the covers of one book, enough at least to fill most of the demands that examinations may make upon them. Books like Wooldridge and Morgan's 'Physical basis of geography' and Tyrrell's 'Principals of petrology' are cases in point. The present book forms another of this class, a textbook which will save the student days of desultory digging. It will please the teacher since it provides him with a fresh assortment of diagrams and illustrations to diversify others perhaps of venerable aspect. The more general reader will find that the book serves as a dictionary to the complicated jargon which physical geographers, in common with those in most other trades and professions, have developed as a device to frighten off laymen and to emphasize the learning needed by all who would profess the subject.

Professor Cotton ascribes his inspiration to W. M. Davis whose treatment of land-forms he describes, codifies, and expands in the light of a wide travel and experience. The theme of the book is the Cycle of Erosion from the cradle to the grave, and the method is one of analysis using examples which he implies are just frames from a cine-film of the changing face of the earth. In a study of land-forms due to structure of the rock below, or to the erosion of river valleys or the ridges between them, or to the building up of lowlands by waste brought down from up hill, or to wind, ice scour, or solution of the solid rock, the author seems to have thought of most permutations and combinations.

After a brief introduction the first chapter is used to describe the features of gravity-born debris where water plays a subordinate role as seen in rock falls, landslides, stone rivers, and stone stripes. The next chapter is an account of the effect of rain on the naked land as it sculptures badlands, tors, and earth pillars in the normal case where it falls nearly vertically, or shaping almost horizontal earth fingers when driven obliquely by a strong prevailing wind. After considering corrosion and corrasion the "long continued progressive erosion following uplift," the cycle of erosion is discussed. The speed at which the early phases of the cycle goes produces different land-forms at first but in the end all are moulded off to form that suave surface, the peneplain no matter how the country looked to start with. Lakes are short-lived phenomena though they vary in duration and form according to the conditions of origin. Warping, faulting, glaciation, vulcanicity, and even wind action may form a basin and a lake, each differing in some feature from the other. The types of rivers are still more numerous and still more factors play their part in their production. A river or part of a river may not be in accord with the land it crosses, for it may

be old and the upland young or vice versa. Then chance may add to the power of one stream whilst another's may wane, and this will lead to a shifting of the divide between them. In extreme cases the drainage of one may be diverted to another where an active river cuts off part of a slothful stream and a suite of special land-forms follows in the train of such events. When rivers drain a land where the rocks are folded the structures exercise some control on the pattern of valleys which is very different from that etched upon a nearly homogeneous cake of the earth's crust. Parts of such a system have contrasting aspects and many of the varieties have special names. Under some conditions rivers cut downwards more than laterally and under others they do the opposite, and all leave marks that the trained scholar can detect. At some periods the rocks may have no cover of soil at all and in others, when an ample protective cloak develops, smooth round-topped ridges may be formed in spite of the urge in orthodox erosion to provide all ridges with a sharp culminating edge.

Many features in the landscape are due to deposition and grade from steep scree slopes at the one end to swampy alluvial flats at the other. They cover large areas and sometimes dominate the landscape, but as they are unconsolidated they are vulnerable to stream attack and suffer at once when there is any differential movement of land and sea. The silty wastes are not peneplains however, for these result only from long erosion under unchanging conditions of climate and elevation no matter how variable and resistant the rocks may be in the crust below. Seldom does the peneplain reach or survive in its perfect state, but patches are left or signs in the landscape point to their former existence though the surface has been carved up after the ravages of a fresh cycle initiated by changes of climate or of level. Depression also takes place and may affect a peneplain by drowning its valleys or silting up the estuaries or introducing unusual features in the river courses. Sometimes the land does not move as a whole but segments of it shift differently on the opposite sides of a fracture. The effect of a fault may be to raise a scarp along it at the time of formation, but much more often rocks of different types and resistance lying on different sides of the fault plane weather differentially to yield rather novel results. The last chapter in the book is devoted to explaining the land-forms produced in an area of soluble rocks where swallow-holes and underground drainage produce in time the harsh rasp of a surface known as karst.

The book is not easy reading and there are some places where jargon runs riot. The plates are mostly excellent and are well described in an index of them. A large number come from New Zealand but others are reproduced from many parts of the world. The line drawings are adequate but do not have the arresting characters of those W. M. Davis used to draw to illustrate his essays. Finally, the title of the book is a misnomer even when modified by the clause "as developed by the processes of normal erosion." Landscape involves something more than land-forms. Who can stand upon a peak of the Cullins and be content to let the glacial basin with its lake, Loch Coruisk and the cirque at its head, or the bay below form his landscape? One cannot neglect the ornament, the sky, the heather, and the sea, and the ever-changing play of colours on each one. Form in an Alpine scene again ranks high, but the glaciers and the woods, the grassy alps and the cloudless blue canopy are as much part of the picture. Where would the landscape in England be if form alone was all it afforded, and it was bereft of its trees, meadows, hedges, and houses, colour and atmosphere? This book has its place, and no mean place, in the library of all interested in geography, but it sails under false colours. It concerns the anatomy, little more than the bare bones of that richly vestured glory known as landscape.

J. V. H.

CARTOGRAPHY

MAP PROJECTIONS IN PRACTICE. By J. H. COLE. Survey Paper No. 45. *Giza: Survey of Egypt*, 1942. 13×8 *inches;* 44 *pages*

This very interesting and useful paper by the Chief of the Geodetic Section, Survey of Egypt, is a valuable pendant to Mr. J. I. Craig's well-known "Theory of map projections" (Survey Dept. Paper No. 13), published in 1910.

Mr. Cole is a welcome recruit to the school of Colonel Sir Charles Arden-Close who has always maintained that one should draw the line at the root of minus one. A simple approximate solution obtained from first principles, which produces formulae very close to the true one, gives, in the writer's opinion, "a better mental picture of what the projection really is than the severely analytical solution of equations derived from complex functions," and by confronting such solutions with those obtained by Craig, he establishes his point: see for example his treatment of the Transverse Mercator on pp. 21–23. He starts with a single simplifying assumption, finds a result very nearly that of Craig, and then advises us to use the latter. His formulae are adapted to computation, and examples are given with the necessary number of significant figures, sometimes nine-figure logarithms.

Besides giving a very clear account of the Survey of Egypt procedure, Mr. Cole makes some interesting judgements: Any country covering 8° of latitude would normally use the Transverse Mercator in preference to the Conical Conformal; a country which "might be considered suitable for representation on the Stereographic projection" can be mapped equally well with either of the former, which in effect leaves the field clear for the Transverse Mercator. And as the theory for this is derived directly from the spheroid, and not by a preliminary conformal representation of the spheroid on the sphere, he has reduced the thing to relatively simple terms. It remains to be seen however how it can be reconciled to Laborde's theory, with his extra constant of integration and scale correction.

Lastly Mr. Cole considers the compilation of a small-scale map from a large number of survey sheets: "It is much easier to draw in the detail if one dimension is true to scale." He sets out the three projections which are true in one direction and have minimum distortion in the other, and considers the choice depends on the shape of the country. But since only one of the three has the meridian at right angles to the parallels, which is equally important in drawing, his argument seems really to indicate a simple conical with two standard parallels [*e.g.* Murdoch's Third, which has additional merits of its own] as the best for a large combined sheet; which is comforting to the calculator of the British Council Map, who has been criticized for not using an orthomorphic projection.

Mr. Cole concludes with a set of tables for Clarke's Figure of 1880 and the so-called International Figure (Madrid, 1924), pleasantly acknowledging "the liberal use . . . made of the tables in R.G.S. Technical Series No. 4." In his Preface he modestly avers that there is probably nothing new in his treatment. But it is in fact very unusual to find so clear and judicious an exposition of this complicated subject, and it will be uncommonly useful. A. R. H.

ECONOMIC AND HISTORICAL GEOGRAPHY

HISTORY AND ITS NEIGHBORS. By E. M. HULME. *New York: Oxford University Press*, 1942. 8×5½ *inches;* 198 *pages.* 11*s* 6*d*

Though written by Professor Hulme, this book is based upon an introductory course for students of history, given by the late Professor G. L. Burr, and was

undertaken at his instigation. Written with enthusiasm and closely argued, it should provoke the reader to much thought, though he may disagree with some of the arguments. Part one discusses the nature of history, general principles of criticism, and interpretation. The second part describes very briefly the purpose of the sciences allied to history, and the help they can render to the historian. In defining history the author urges that the historian must choose out of the vast number of historic facts, vast yet a mere portion only of all that has happened during man's life on the earth, those which help the understanding of the past as a key to the present, taking account of thought as well as deed. This selection will depend to some extent upon the individuality of the particular historian, and this will become more marked in his interpretation. For these reasons Professor Hulme maintains that no historian can be really objective, though he should strive to be as disinterested as possible. Some readers may feel that history, unless it can be objective, loses much of its value, except perhaps as material for future historians. They may also regret the author's contention, in contradistinction to Lord Acton, that an absolute moral standard cannot be applied to past ages. Indeed in one place he maintains that standards of morals are purely determined by contemporary social usage, "that the likes and dislikes developed by man in his social life are coming to be the true foundation of morality." Many passages in recent history surely show whither such morality must lead.

The sections on the character of historical material and the methods of handling it, illustrated with many interesting examples, are clear and concise. The second part, necessarily compressed, should broaden the outlook of the student. It may startle the geographer especially after having read earlier a discussion favouring geographical possibilism as against determinism, to find that "the difference between geology and geography is not easy to define." In general, with reference to the related sciences, the author adopts the evolutionary view, while stressing that evolution does not necessarily imply progress.

G. R. C.

GENERAL

THE WESTERN FRONT: a geographical approach. By GRIFFITH TAYLOR. *Toronto: Ryerson Press*, 1942. $7\frac{1}{2} \times 5$ *inches;* 28 *pages; sketch-maps.*

Professor Griffith Taylor has written an attractive pamphlet which should be a delight to the amateur strategist who has slight geographical background. This pamphlet emphasizes the essentials of European structure and relief and so avoids the errors of judgment due to arguments based solely on an orographical map. Certain unbalanced statements, caused largely by over-simplification, mar the geographical picture. In Fig. 2 for example it is suggested that the Alps have a simple anticlinal structure, with escarpments formed by what the author terms "hard rocks," and this diagram is essentially no different from many used to illustrate the structure of the Weald. Similarly the definition of a graben is not clear to a lay reader. The map (Fig. 1) which shows the London–Paris Basin and the text on p. 17 do not agree with the more correct map on p. 16.

Sometimes too much is claimed for structure control, *e.g.* other factors than "similarity in structure" explain why the French government moved from Paris to Bordeaux in time of war. The concluding pages of the text, where it is suggested that Emden to Bremen offers the best stretch for a successful bridgehead when invading the continent, give rise to the possibility of an interesting counter-argument for a discussion group. Despite its blemishes this pamphlet is to be recommended as providing for many a new outlook on the background of the west European war theatre.

A. C. O.

THE MONTHLY RECORD

THE LEARNING OF LANGUAGES

Between January 1940 and April 1941 a series of articles on the learning of languages appeared in the *Journal of the United Service Institution of India* over the *nom de plume* of Karshish. They have been helpful to the work of the P.C.G.N., and are recommended to those interested in the official use of language, and in Near and Middle Eastern affairs. Karshish seems to be a military intelligence officer, who served in the Near East during the war of 1914–18 and in the Middle East afterwards. He had unusual opportunities for observation during his active service, and for travel, study, and reflection between the wars. Looking back on his experience as a young man and as a mature officer, he is convinced of the primary importance of language, properly used; and these spirited essays on the languages he now knows begin with one on his own. "Plain English" (*J. United Serv. Inst. India*, 70 (1940) 87–94) has the sub-title "Some notes on translation," and is a plea for the use of simple, direct, and concrete English in official translations instead of jargon, however well approved, or of affected style, however elegant. The series continues with "Learning Turkish" (*ibid.*, 161–76); "Learning Russian" (*ibid.*, 259–71); "Learning Persian" (*ibid.*, 362–74); "Learning Greek" (*ibid.*, 71 (1941) 35–47); and ends with "Learning Hindustani" (*ibid.*, 129–40). In the last, the claims of Urdu and Hindi are considered, and the Indian examination system is criticized. The other articles are written from the point of view of the beginner studying abroad, and give the results of personal experience in finding native teachers, in choosing text-books and dictionaries, and in encountering and mastering the peculiarities of syntax of new languages. In each instance an example, such as the use of the indeclinable relative in modern Greek, is so neatly chosen as to make the language under consideration stand out alive and unique. The experience of studying Oriental languages in stormy times and in an atmosphere of international intrigue is conveyed with a degree of lucidity and insight sufficient to give these essays historical importance. They should be re-issued in book form. M. A.

THE HISTORY AND ENVIRONMENT OF THE INDIANS OF ARIZONA

From 1935 to 1939 the Peabody Museum of American Archaeology, Harvard University, made general surveys and excavated twenty-one ancient sites in the basin of the Jeddito river of north-east Arizona. The area lies in the Hopi and Navaho Indian Reservations and includes several stretches of Mesa land as well as the valleys which separate them. Two Reports, Peabody Papers, vol. xxxv., Nos. 1 and 2, have been received and others are in preparation.

The first report under the title 'The changing physical environment of the Hopi Indians of Arizona,' by John T. Hack, is an important document in human geography. The great ruins of Awatovi cover 23 acres and mark an Indian occupation from the thirteenth to the eighteenth century, to which was added a large Spanish Franciscan missionary establishment during the seventeenth. Other Pueblos and smaller sites extend the period covered from about A.D. 500 to the present time. "One of the most important aspects of the study is the fact that the history so preserved represents an unbroken current of cultural development which is still flowing in the modern Hopi towns and farms." For geographers there is a special interest in the adaptation of this civilization to the physical environment, which is not only of a somewhat uncommon type

unrepresented in Europe, but also shows important changes within the period. A sentence from the Preface by J. O. Brew, Director and Editor of the expedition, should be taken to heart by all organizers of archaeological expeditions: "the fact that we should need a geologist and physiographer on the staff became apparent during the first season." Dr. Hack joined the staff in this capacity in 1937.

The dominant feature of the country is the Black Mesa, a tableland formed by a sandstone of Upper Cretaceous age, cut up into fingers by the valleys of washes or intermittent streams flowing to the Little Colorado river; in these the underlying shales with their limestones and coals are exposed. The streams bring sand and silt from the Black Mesa to the lower plains, where the prevailing south-west winds separate them and carry the sand back northward to bank it against the escarpment in dunes. The rainfall nowhere exceeds 13 inches, but the dune sands have a lower run-off after the summer rainstorms, and consequently more permanent springs than in other areas with similar climate nearby. Special methods of farming have therefore been developed. The Hopi raise corn and beans in four types of field of which the more important are flood-water and sand-dune fields. The former are used on the low ground where the flood-water spreads in thin sheets and the relatively high moisture-content of sandy soils can be utilized.

The question of water supply is discussed in considerable detail; the abundance of springs is in part due to the general lack of vegetation which reduces loss of water by transpiration. In this connection a curious reversal of normal cause and effect arises: parts of the area are to-day less thickly populated than in pre-Spanish times; consequently the water supply is less, because cultivation reduced the total vegetation. Equally surprising is that the Spaniards caused a change of the chief fuel from coal to wood.

The sand-dunes have been fully studied and afford a means of determining changes of climate in the last few thousand years. "Changes in the violence of wind action must be the result of a change in the plant cover to a more or less aggressive plant association. This change in plants is presumably the result of a change of climate." This passage from the Conclusions rather suggests an argument in a circle, but from about 9000 B.C. to A.D. 1000 the temperature and moisture changes inferred correspond with the general history of the continent, showing a maximum warmth, the Post-Glacial Optimum of some writers, round about 5000 B.C. and for more recent times the deductions can be to some extent confirmed by a study of tree-rings. During the first millennium A.D. the climate was apparently moister and cooler than it is to-day, for areas which now contain active dunes then contained stabilized dunes which in some places had developed a hard crust of caliche. During the second millennium increased wind action can be dated as during or since Pueblo III times.

In the areas of moving sand the fields were protected by lines of stones holding down brush, preventing the sandy soil from being blown away and protecting the plants from sandblast; the tracing of ancient field systems depends on these lines of stones, though the brush has perished. In these fields deep-rooted plants were grown which can reach the zone of saturation at depth or the capillary fringe above it. In the lowlands irrigation was used to grow onions, cabbages, turnips, carrots, chili, and tobacco; the necessary terracing can be traced and dated, since the physical history of the watercourses has been worked out: the washes were cutting down in Pueblo III times but aggrading their valleys in Pueblo IV, which centres round A.D. 1700.

The general results are summarized in the form of a graph of the population density from about A.D. 500 in the period known as Basket-maker III, through

the various Pueblo times to the present day in Pueblo V. From about A.D. 900 to about 1450, in Pueblo IV there is a steady rise, followed by a more abrupt fall to a minimum about three hundred years later. Besides maps, sections, and graphs, the report is illustrated by well-reproduced photographs.

The second report deals with the mining and utilization of coal by the Indians. Coal seams occur in the Upper Cretaceous shales beneath the sandstone which forms the Black Mesa. The quality is somewhat poor and the high sulphur content must have made the smoke unpleasant; nevertheless the total amount mined is thought to have exceeded 100,000 tons, and of this at least 90 per cent. was carried to the houses for domestic fuel. Many of the heaps of coal ash can be dated and show the use of the material during the Pueblo III, IV, and V periods, say thirteenth to seventeenth centuries A.D. At least during Pueblo IV coal was also used for firing pottery, the ash heaps, one of which contained a batch of completed pots in addition to sherds, being conveniently near the coal outcrops. Strip-mining was the chief method, that is to say the overburden was removed and the exposed coal collected from the open surface, a method which has become prominent in England during 1942. Underground mining was resorted to when the overburden became excessive: both pillar and stall and longwall workings have been found, and in the latter the goaf is built up with waste material to support the roof, exactly as in modern practice. Coal working ceased with the advance of Spanish civilization; the Spaniards introduced sheep, whose dried dung was used in the pottery works, and iron axes made the cutting of wood for household use less laborious.

It will come as a shock to most British readers that the report is entitled 'Prehistoric coal mining in the Jeddito Valleys'; in fact it invites several comments on the use of words. The word Prehistoric must always be understood in relation to the particular area, for example we all know that it means something very different as applied in Egypt or Mesopotamia from that in our own country; it is illogical but natural to experience a momentary perplexity when we find the word rightly used for the thirteenth to sixteenth centuries A.D. Again we are told that there are over 14 billion tons of coal in the Black Mesa field; an Englishman must remember that an American billion is one-thousandth part of an English billion. The section of a seam is given as consisting of three layers of coal separated by bone; the bone appears to be what we should call dirt, not a splintery cannel such as is sometimes known as bone in the north of England. The mining technique always known in England as "pillar and stall" is here "room and pillar."

The report concludes with a useful bibliography of all kinds of aboriginal mining in the United States, including such substances as turquoise and flint, a subject which should be studied for the light thrown on equally primitive, though vastly older workings in Europe, Asia, and Africa, where some flint mines are even prehistoric. C. N. BROMEHEAD.

REPRODUCTION OF OBLIQUE MERCATOR PROJECTIONS

A grant from the Leverhulme Trustees has enabled the Society to produce by collotype, with black outline and blue sea, a small edition of six Obliques, one Normal, and the Transverse Graticule, on sheets 20 by 12½ inches, to the scale 360° = 17 inches. Five of the obliques have a pole of the central axis in the same latitude 35½° N. and in longitudes 202°, 272°, 332°, 2°, 92° East, of which the first, third, and fifth are respectively B*, D, and F of the series of six shown on a very small scale in the *Journal* for June 1941. The sixth oblique reproduced is a finished version of map L of the same paper, with pole 28° N. L. 105° E.

Copies have been presented to services interested in the problem of finding long great-circle courses and distances in all parts of the world, and the Secretary will be glad to hear from officers of the Allied Forces and others who wish to use the maps and graticule in the course of their duties. The maps are not at present on sale.

As an example of their use, we may take the problem of setting out bearings and distances from a radio station. Certain stations have had calculated for them zenithal-equidistant projections centred on the stations. These give directly true bearings and distances, but they have the great disadvantage that the antipodal point of the station is represented by the whole circumference of the projection, so that the distortion is immense and it is difficult to draw and impossible to recognize the outlines of the land. Such a projection centred on Valparaiso would have the whole circumference occupied by a point in Eastern Asia.

On an Oblique Mercator the radial lines from a station are curves, easily plotted from the transverse graticule, and marked off in thousands of kilometres. They converge to the antipodal point, and the distortion there is precisely the same as that round the original station. It would be necessary to use two charts to cover the whole world, but the outlines would be already drawn, and the curves for any station could be sketched in a few hours.

To plot a great circle on a given azimuth A from a station in lat. $\phi°$ long. $\lambda°$ one calculates the latitudes ϕ in which the curves cut the meridians $\lambda° \pm 90°$, from the simple formula $\tan \phi = \cot A \sec \phi°$; plots these points, and finds in the usual way the great circles joining $\phi°$, $\lambda°$ to the series of points ϕ, $\lambda° \pm 90°$.

A. R. H.

TEXAS OIL

In the October *Journal* it was stated that a pipe-line had been laid from Longview in north-east Texas to Salem in Illinois, and this pipe-line was also shown on the sketch-map. Professor Barbour has since written from Cincinnati that "the new pipe-line ends at Norris City Ill., not at Salem as was first intended."

OBITUARY

PROFESSOR JOHN NORMAN COLLIE, F.R.S.

Norman Collie was the last survivor of the famous party led by A. F. Mummery, and including Geoffrey Hastings and General (then Captain) C. G. Bruce, which may be said to have inaugurated the present-day form of guideless mountaineering. He was a most beautiful rock-climber, strong and absolutely safe, and was also highly proficient on snow and ice, as was shown in his great performances on the Brenva slopes of Mont Blanc in the double attempt of 1892, finally crowned with success.

Collie was the topographer of the Mummery party which made the triple first attempt on Nanga Parbat in 1895. He was engaged in collecting stores when the fatal accident to Mummery and his two Gurkhas occurred, and he always considered that Mummery, relying on his great skill, had taken unjustifiable risks on the three attempts.

In 1896 Collie made his first of four visits to the Canadian Rockies on a search for Mount Hooker and Mount Brown, which had been reported by

David Douglas as very high, *c.* 15,000 feet. In that and the following year he explored the then unknown country between the headwaters of the Saskatchewan and the Columbia rivers, then recently made accessible by the C.P.R., but still difficult of approach because of the fallen timber in the valleys. In the second year he succeeded in identifying the two mountains, but found them of the modest height of 9000 feet, explored the Columbia ice-field, and climbed Mount Athabaska (*Geogr. J.* 13 (1899) 337). He returned to the Rockies in 1900, exploring the Bush river approach to the range from the west (*Geogr. J.* 17 (1901) 252), and made a fourth journey of exploration to the country north of the Yellowhead Pass in 1910 (*Geogr. J.* 39 (1912) 223).

Meanwhile he had climbed in the Lofoten Islands (*Alpine Journal*, 21 (1902) 90), and had published two books: 'Climbing on the Himalaya and other mountain ranges' (Edinburgh: Douglas, 1902): the other ranges including the Lofotens and McGillicuddy's Reeks; and (with H. E. M. Stutfield) 'Climbs and explorations in the Canadian Rockies' (London: Longmans, 1903).

Having been Vice-President of the Alpine Club in 1910–12 he served as President in 1920–22; was an original member of the Mount Everest Committee, and succeeded Sir Francis Younghusband as its Chairman in 1923. His remarkable instinct for mountain geography may be judged by his interpretation of Kellas's photographs from the Kang La in the discussion before the first Mount Everest Expedition of 1921 (*Geogr. J.* 57 (1921) 273). His skill in photography of mountains was shown especially in the Himalaya, the Lofotens, and in Skye.

Collie was elected a Fellow of the Royal Society in 1896. From 1902 to 1928 he was Professor of Organic Chemistry at University College, London, retiring in 1928 with the title of Emeritus Professor. For the Nanga Parbat expedition he invented a portable Mercury barometer with a flexible tube of rubber, used later with success by Captain Deasy (see article by Deasy in *Geogr. J.* 10 (1897) 203, with a note by the inventor). To his other scientific attainments may be added that he was a remarkable judge of French red wines.

In his years of retirement he lived in his beloved Skye, and died at Sligachan on 1 November 1942.

He became a Fellow of our Society in 1897: was a member of Council from 1902–06, and 1921–24, and Vice-President from 1924–28. E. L. S.

CAPTAIN GEORGE TYRRELL McCAW, C.M.G., O.B.E.

Geographers and surveyors throughout the Empire will learn with regret of the death of Captain G. T. McCaw, who died at his brother's house in Northern Ireland on 17 October 1942. McCaw had for many years been closely associated with Empire surveys, and to all those (and they were many) who at any time came to him for advice or assistance he was, in the truest sense, guide, philosopher, and friend.

McCaw started his career in the Valuation Department of the Irish Civil Service, but subsequently became one of Sir David Gill's staff at the Cape as an observer on the primary triangulation of South Africa. In 1903–6 he was Chief Assistant under Dr. Rubin on the geodetic survey of the 30th Meridian arc in Rhodesia. This work was, towards the end, faced with great difficulties owing to lack of funds (due to the death of Cecil Rhodes who had given a guarantee), but McCaw characteristically struggled on for some months under the most Spartan conditions, in order that the scientific work should not suffer.

McCaw next went to Uganda, where the Anglo-Congolese Boundary Commission under R. G. T. Bright had been engaged on a topographical survey of

the western frontier. Advantage was taken of this to add another portion to the geodetic survey of the 30th Meridian arc, and when the rest of the Commission went home, Major (later Brigadier) Jack remained, and with McCaw, who supplied the technical knowledge, carried out the geodetic triangulation (1908–9) working southwards over the ground previously covered by the Boundary Commission, whose survey provided a valuable reconnaissance.

Soon after the termination of this work, McCaw went to Fiji, where he carried out the primary triangulation of the islands (1910–15), and where he made practical use (it is thought for the first time) of photographic survey with Major Vivian Thompson's stereo-plotter. He came home as soon as possible on the outbreak of the Great War, and was soon given a commission in the Royal Engineers, going to France in 1916 as a Captain on the staff of his old chief, now Colonel Jack, who was in charge of map supply and survey work at G.H.Q. There he found awaiting him many novel problems connected with map projections and trigonometrical adjustments with which he was particularly well qualified to deal. The introduction of rectangular grid systems had raised a number of new problems, to the solution of which he made a notable contribution. McCaw remained at G.H.Q. until the end of the war. So highly had his services been valued by his chiefs that after peace was restored a special post was created for him in the Geographical Section of the General Staff. Here his primary official task was the study of the triangulation systems and map projections of foreign countries, and the application of military grids thereto; but it was not long before the mathematical and geometrical problems of air photographic surveying attracted his interest. On the formation of the Air Survey Committee in 1921 he became its Secretary, retaining this appointment until his retirement from the service in 1935. McCaw made many contributions to the science of air survey, and much of the nomenclature now in use is due to him. He had a good deal to do with the design of the first air-photo plotting machine produced in this country, sometimes known as Big Bertha.

While at the G.S.G.S. McCaw took a leading part in the organization of the periodical conferences of Empire survey officers, and there is no doubt that his many friendships among Colonial surveyors, as well as his genial personality, contributed not a little to the success of these gatherings. It was at one of these that the idea of the Empire Survey Review was propounded by Brigadier Winterbotham. It was greeted with enthusiasm by all present, and in due course the approval and backing of the Colonial Office was secured. There was general agreement that McCaw should be its first editor, and it was fortunate indeed that one so eminently qualified was available to launch the new Journal on its career. Right well did he discharge the task. The starting of a new magazine is however no light undertaking, and it was impossible for McCaw, already fully occupied with his official duties, to deal with the whole of the work. Fortunately a competent assistant was found for him in the person of the late J. H. Reynolds, who, until his death, relieved McCaw of much of the routine and administrative work of production. McCaw made many contributions to the *Empire Survey Review* from his own pen. It was indeed quite remarkable how he seemed able to bring out from the rich store of his memories something interesting and new whenever the supply of material from other sources threatened to fail.

McCaw's eminent services to Empire surveying were recognized by the award to him in 1936 of a C.M.G., a well-deserved honour which gave much satisfaction both to him and to his many friends and admirers.

Although at the time of his death McCaw was a leading authority, with a world-wide reputation, on geodesy and almost all branches of surveying, no

one would have known this from his own admission. He was one of the most modest and unassuming of men. No one ever heard him claim credit for himself; never did he blow his own trumpet, though very ready at any time to sound a call for others. His was a lovable character. His friends were legion, and it is safe to say that he had no enemies. A host of men in all parts of the world, who have benefited by the help which he was always ready to give from his wide experience and knowledge, will long remember his courtesy and great kindliness, and will mourn the loss of a wise counsellor and a true friend.

M. N. McL.
E. M. J.

MAJOR-GENERAL SIR CECIL PEREIRA, K.C.B., C.M.G.

Sir Cecil Pereira was a distinguished officer of the Coldstream Guards, which he joined in 1890, and saw early service in the Niger Territory and in Uganda before his appointment to the Rhodesian Field Forces in the South African War. During the war of 1914–18 he commanded in succession a battalion of his regiment, the First Guards Brigade, and the Second Division, having been promoted Major-General in 1918. After that war he commanded a division of the Territorial Army.

He had been a Fellow of our Society for fifty years, served on the Council from 1938 until his death, and was a regular attendant at our Meetings. On the day of the opening Meeting of the present Session his many friends on the Council heard with great concern that he had been seriously ill for three months, and he died on that day October 26 to the lasting regret of all who had for him an affectionate regard and admiration.

MEETINGS: SESSION 1942–43

First Meeting, 26 October 1942. The President in the Chair

Elections: Major G. Smedley Andrews, R.C.E.; Lieut. R. Atkinson, R.N.R.; Miss G. M. Burton; Rev. G. A. P. Cooper; 2/Lieut. B. Hughes Farmer; Mrs. G. B. Hooper; Professor E. R. Hondelink; C. J. Juta; D. T. Lees-Smith; The Dowager Lady Loch; Rev. E. E. J. Martin; J. N. Miatt; Major S. Murfin Rose, R.F.; L. N. Nicholson; Mrs. Helen M. Rait Kerr; U. Tawfiq; J. M. Townsend; Henry R. Wallis; Capt. A. M. F. Webb; Mrs. Reginald Wyndham

Paper: A new era in the Gobi. By Miss Mildred Cable

Second Meeting, 9 November 1942. The President in the Chair

Paper: Forecasting run-off from snow surveys. By Capt. R. C. Farrow, R.C.A.

Third Meeting, 16 November 1942. The President in the Chair

Elections: Miss Lilian Barker; Henry James Etchells; Arnold D. Griffith; Robert S. Hammond; Noel Quintin King; Edward Newhouse; Rev. Arthur W. Robinson; William James Rowlands, B.A.; Miss Joyce L. Watford

Paper: The southern face of Mount Everest. By Lieut.-Col. L. V. S. Blacker

Fourth Meeting, 23 November 1942. The President in the Chair

Geographical Films: Halifax to Victoria B.C. Commentary by Mr. C. W. Stokes.